

The Effectiveness of Using Coloured Blocks in Teaching the Concept of Balancing Chemical Equation in Chemistry

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Abstract. The aim of this study is to study the effectiveness of using coloured blocks in teaching the concept of balancing chemical equation in chemistry. It is expected that students will improve their understanding in this concept and students interest in chemistry. This study examined how by using coloured blocks will help students understand the concept of balancing chemical equation which is an important concept to master in Form 4 Chemistry. Using pre and post-test control group design, the study involved a comparison between a control group (n=20) which were taught using the conventional chalk and talk method to balance chemical equation while the treatment group (n=20) were taught to balance chemical equations using coloured blocks. After pre-test, there was a significant difference between control and treatment group on their post-test scores with effect size of 1.31. Students who had used coloured blocks to balance chemical equations showed significant development in their post-test compared to the students who were taught using the conventional method. Students also showed high interest in chemistry upon using coloured blocks in teaching the concept of balancing chemical equation. The research results recommended the use of coloured blocks as a potential tool to teach the concept of balancing chemical equations..

Keywords: *Coloured blocks, Chemical equation, Chemistry, Concept of balancing.*

1 Introduction

Chemistry is one of the most vital subjects one has to master in order to be a science stream student. Chemistry is a science stream subject which focuses on structure, composition and the state of matters that exist in the world. The application of Chemistry can be seen in various fields such as Medicine, Pharmacy, Physics, Biology and Technology. However, many secondary school students find Chemistry subject to be challenging and difficult to understand due to its abstract content. Students need to visualize matters in order to understand simple definition or process. Chemistry is an important field of science and students have difficulty understanding abstract concepts, because chemistry curriculum is composed of many abstract concepts or theories it is very difficult to be understood by students (Sirhan, 2007; Taber, 2002; Zoller, 1990).

The fundamentals in Chemistry must be embedded in students mind especially during the first few classes of the subject to build a good impression that it is not a difficult subject to master. Otherwise, students will grow less interest and become passive during the teaching and learning in class. Teaching and learning practices employed by teachers often do not develop students understanding in forming of chemical bonds and reactions but more towards memorising the whole chemical equations. Due to this, students do not require mastering the skill to balancing the equation but simply memorise without actually understanding the method. According to El Hassan Touli et al. (2015), in the teaching of science in general, and chemistry in particular, the main mission is to help students develop an understanding of the natural world and its phenomena from a scientific approach. When it comes to understanding a particular process in chemistry, this can be done by scientific experiments in the laboratory but to understand a certain theory or concept, more hands on activities is encouraged to develop the ideas in the student's mind.

A teacher will be able to change the mindset of the students by exploring different methods and teaching style in chemistry class. Many teachers have done researches on issue the mole concept, atomic structure, thermodynamics, electrochemistry, covalent bonding, ionic bonding, and gases for some decades (Gilbert & Watts, 1983; Dogar et al., 2011; Gurses et al., 2002; Ozmen & Ayas, 2003). These researches did not explore the methods to teach balancing chemical equation in chemistry. The concept of balancing chemical equation is important because it is the most basic skill a student has to acquire to master the subject. This will also help them to understand the following chapters in the subject. Educators assert that knowledge is enhanced when students are actively engaged in the learning process and when this is coupled with guidance and scaffolding from the instructor, students are able to gain a better understanding of science concepts (Correio, Griffin & Hart, 2008; Martin-Hansen, 2005; Lindquist, 2001). If the teaching of balancing chemical equation is not done with students actively engaged in class, the concept will not be embedded in the minds of the students.

Ahmet Gurses et al. (2015) states that common use of the teacher-centered teaching has attracted the attention. The traditional approach orients to memorizing, makes the students accustomed to the prepared one, negatively affects the sense of curiosity and causes raising individual who do not question. Maria Fatima Morais and Ivete Azevedo (2010) which states that in the context of the school, the teachers are not only a source of information to students, but also act as a role model for students. Therefore, to realize that the curriculum into an opportunity to develop creativity (Park et al., 2006), teachers should use the opportunity to practice creative teaching practices in the classroom. Thus, it could enhance creative thinking among students. There is no previous research being conducted using coloured blocks in teaching chemistry. Therefore, using simple coloured blocks in class during the lesson of balancing chemical equation will be a creative way to teach. Coloured blocks are cheap, readily available at the kids store or hypermarkets. Students are able to have more blocks to construct the chemical equation without having to share or wait for turns.

This study aims to determine the effectiveness of using coloured blocks in teaching the concept of balancing chemical equation in chemistry. This study will help and guide teachers to improve the lesson in class and also give students a brief idea on

how to represent atoms and molecules. This study also measure the understanding of students before and after using coloured blocks in teaching the concept of balancing chemical equation in chemistry. This will explore how much variation in the chalk and talk method and with using coloured blocks in teaching and learning of balancing chemical equation. Apart from that, this research also aims to rise the percentage of students getting A+ in SPM examination and lessen the number of students deteriorating in Chemistry subject. By getting to the root of the problem faced by the students in Chemistry subject, and applying new method and approach in teaching and learning in class, students will be able to discover new and creative ways in learning Chemistry and at the same time to analyse the effect of using coloured blocks in teaching the concept of balancing chemical equation in chemistry upon students interest. The first objective of this study is to determine the effectiveness of using coloured blocks in teaching the concept of balancing chemical equation in chemistry and the second objective of this study is to analyse the effect of using coloured blocks in teaching the concept of balancing chemical equation in chemistry upon students interest.

1.2 The Science Education and Chemistry Subject

In Malaysia's secondary school curriculum, the concept of balancing chemical equation is introduced in the syllabus of Chemistry form 4 Chapter 3 Chemical Formula and Equation. It is a concept students will be required to master to enable them to understand the following chapters such as Periodic Table, Acid and Bases, Salts, Rate of Reaction, Oxidation and Reduction and Thermochemistry.

Based on the statistics of the Sijil Pelajaran Malaysia (SPM) year 2015 analysis, it is shown that there is a slight decrease in the achievement among students whole Malaysia in Chemistry subject. (Lembaga Peperiksaan, 2015) The percentage of students obtaining grade A+ also decrease. This is a sign that students are unable to master that subject compared to other pure sciences subject such as Biology and Physics. The main reason for this to happen is students have very weak basic Chemistry skills and one of the most difficult skill students struggle is balancing chemical equation in Chapter 3 Form 4. Students are unable to learn this skill on their own without the guidance from the teachers so strategic approach in teaching and learning must be planned in order to master this skill. When the most important skills which is balancing equation is not mastered, students will encounter complications in answering examination questions which comprises basic theory, concepts and application of Chemistry in daily life.

1.3 Creative Learning Environment for Science

In recent times, various new ideas were introduced by many researches including the use of software, modern technology and multimedia to improve teaching and learning in class. Unfortunately, many schools in Malaysia are still experiencing lack of money and resources to have more computers, interactive whiteboard or even LCD projectors. Not only that, the readily available molecule structure model is way too expensive to be purchase in large amount for all and will not cater to huge classroom students. Due to this, teachers have no other option but to use other tools to help with the process of teaching and learning in class instead of relying only on chalk and talk method. Recently, several approaches have been

established to provide a strong learning environment. The most important requirement for all of these approaches is to find firstly, the teacher who is well-trained and have the desired characteristics (Germann et al., 1996; Schelfhout et al., 2006; Tynjala, 1999; Rasul, Bukhsh & Batool, 2011; Özbay et al., 2012; Tulbure, 2012). Most students view science as an uninteresting subject, and often feel lost when learning science because they felt the topics discussed were not relevant to their daily life experiences (Othman Talib et al. 2014). It has been suggested that the teaching and learning of science should involve the use of digital materials which is found to be more exciting in fostering students' interest and engagement in learning science at the primary school level, and is likely to sustain and extend student's interest in science up to the higher level of studies (Akpınar, Yıldız, Tatar, & Ergin, 2009).

Usually, teachers in primary schools prefers to perform exciting activities that promote lively and fun participation during science lessons. These activities usually encourage students take part in the lesson and at the same time capture the concept of knowledge that the teacher wanted to embed in their minds. Unfortunately, when it comes to secondary school students, teachers find that fun learning are no longer suitable for teenagers and teachers are back to traditional method of teaching and learning. According to (Adzliana et al., 2012), to cultivate creativity in science learning as learning science especially subject such as Chemistry requires students to have high imagination in order to visualise abstract contents. When science teachers are creative in changing the pedagogy of teaching science in class by being more creative, this will surely develop students interest in science. This creativity will also encourage innovative minds in our students in line with the development of technology and globalisation.

Creative pedagogy would be best for students who are not able to visualise the mechanism of the reactions in organic chemistry. Most students will be able to obtain information more in visual form rather than words. This method will surely increase students' engagement in class and will be able to solve problems related organic chemistry. Mayer and Moreno (2002) believe that animation has the capability to make an abstract concept at the macroscopic and microscopic levels easier to understand. They conducted extensive studies on the use of animation in diverse learning contexts. The studies found that animations increase student engagement and bring about a significant improvement in learner's problem solving skills. However the studies revealed that if animations are too complex and dynamic, students will face difficulties to extract information from the animations (Ayres, Kalyuga, Marcus & Sweller, 2005). These animations impose an extra cognitive load on students (Gilbert, Reiner & Nakhleh, 2008), thus prove to be unsuitable for learners.

According to Kalem and Fer, (2003), the most important characteristics of active learning is to integrate the student with the real life, actualize the permanent learning, and provide meaningful learning. The five types of creative learning activities in science is similar as suggested by the Qualifications and Curriculum Authority (2005) in Cheng (2011). For example, scientific discoveries involving the question and challenge the understanding of knowledge involves a look at the relationship. Further, the fifth type of design also includes several suggested teaching strategies in the model of Williams (1969). For example, the presentation

of knowledge involves the use of analogy, creative writing and visualization skills. Overall, the methods mentioned can shape students' creativity through science.

A similar approach that was conducted by Marais (2011) which used Lego® blocks as a simple tool to teach physical and chemical change in first year Foundation Chemistry university students. This study proved that the first-year Foundation Chemistry students can demonstrate a clear understanding on chemical bonds when they used coloured Lego® building blocks. This research proved that 'hands on' activity improves the understanding of chemical concepts in students. Generally, pictures and structured diagrams are more comprehensible than just words, and are better able to illustrate complex topics (Davies, 2011).

In addition, Cheng (2004) has presented a comprehensive strategy statement to create a creative learning in physics. Hu and Adey (2002) also suggested a model which includes the questioning of scientific creativity, divergent thinking and thinking some other elements in the scientific imagination, inquiry and innovation. Cheng (2006) had also proposed a comprehensive model in the physics curriculum. Not only that, Kind and Kind (2007) also found a different approach to creative learning in the context of science education. This includes an open inquiry, creative problem solving, creative writing, metaphor and an analogy. According to (Vebrianto & Osman, 2011), creating multiple learning environment ensures that students reach the information by themselves. Curriculum more challenging world of today in line with developments in the globalization of society demands higher educated and has high creativity. Through science education, many scientists can be trained in line with the nation's progress towards the direction of science and technology. (Adzliana Mohd Daud et al. 2011)

1.4 Model of Curriculum Development

This study revolves around the Model introduced by Lawrence Stenhouse which is the Stenhouse model (1975). Lawrence Stenhouse (1975) who produced one of the best-known explorations of a process model of curriculum theory and practice. He defined curriculum tentatively: 'A curriculum is an attempt to communicate the essential principles and features of an educational proposal in such a form that it is open to critical scrutiny and capable of effective translation into practice'. He suggests that a curriculum is rather like a recipe in cookery. This model suggest that a curriculum should deliver a basis for planning a course, learning it empirically and considering the grounds of its explanation. It should offer firstly, the principle for the selection of content, secondly, the principles for the development of a teaching strategy which focuses on how it is to be learned and taught. Thirdly, the principles for the making of decisions and the last principles on which to diagnose the strengths and weaknesses of students. In this study, the focus is on the second principle which is the principles for the development of a teaching strategy or method which emphasizes on how the concept is learned and taught.

2. Methodology

In order to achieve these objectives, the pre-test and post-test control group research design, which is a quasi-experiment research design was used in the study. For this reason, 40 students attending Form 4 Science stream in one of school in Taman Petaling were chosen as sampling groups and were divided into two groups including 20 students as the control group and 20 students as the treatment group. The chemical equations are within the scope of the syllabus for Form 4 Chemistry. In the control group, the balancing of chemical equation was instructed through the conventional method by the same teacher. In the treatment group, the balancing of chemical equation was instructed using coloured blocks in the same period.

This study uses pre-test, post-test and a questionnaire which were administered to both control group and treatment group. The pre-test and post-test consist of 10 questions of balancing chemical equation was prepared to cover the determined achievements. The questions for the test were created by the researcher. A pre-test was conducted on both groups. The control group was instructed with conventional method while the treatment group was instructed using coloured blocks to teach balancing chemical equations. After that, the post-test will be run to the treatment group and the control group. A questionnaire which comprises of 10 questions with 5 choices Likert scale was given to each students to analyse the interest of the students from both groups. The questionnaire was adapted and modified from the Teacher Enrichment Initiatives 2009 The University of Texas Health Science Center at San Antonio.

In the process on data collecting for this study, pre-test was conducted on 40 students of science stream from this school. The test was then evaluated their marks were analysed. The conventional method and using coloured blocks method to balance chemical equation were instructed to both control group and treatment group respectively. Then, the post test and the questionnaire was conducted immediately on both groups, evaluated and analysed. The pre-test and post test data was analysed quantitatively using the SPSS 19.0 package software. From this analysis, t-test was carried out to determine if there was a statistically significant difference between the control group and experimental group.

3 Results ad Discussion

The pre-test which consist of 10 chemical equations to be balanced that was conducted on both groups shows that there were no significance difference in both group results. This clearly indicate that both group are in the same level of understanding the concept of balancing chemical equations. A questionnaire on investigating student's interest in the concept of balancing equation and chemistry subject was done to both control group and treatment group. Both groups shows a fair interest in the chemistry subject. For the first part of the analysis, the normality and the conditions homogeneity were analysed using Shapiro-Wilk test. From this test, it shows the significant value $p > 0.05$ which specifies that these data were attained from a normal distribution. This can be seen in Table 1 below.

Table 1: Test of Normality using Shapiro-Wilk test

	Group	Statistics	Df	Sig
Pre test	Treatment	0.940	20	0.241
Post test	Control	0.955	20	0.445
Pre test	Treatment	0.954	20	0.431
Post test	control	0.968	20	0.723

The results of the pre-test were analysed using independent t-test. The results of the students pre-test from both groups are presented in Table 2. There was no significant difference between the pre-test average scores of the treatment and the control groups, $p > 0.05$. This indicates that both groups are in the same level of understanding before both the methods were used to teach how to balance chemical equations.

Table 2. Independent t-test results of pre-test

Group	N	Mean	Std Deviation	t	P
Treatment	20	50.25	18.244	0.463	0.794
Control	20	53.00	19.290		

Both groups were taught how to balance chemical equation where the control group experience conventional method whereby the teacher uses chalk and talk method to teach how to balance the chemical equations. The treatment group was introduced with coloured blocks to assist in balancing chemical equations. The post-test was conducted immediately to both groups and their results were analysed using t-test.

According to post-test results, the treatment group students showed more success than the control group students. A statistically significant difference was determined between the post-test scores. When the groups' post test scores were analysed, it was observed that the standard deviation of the treatment group ($M_{\text{treatment}}$: 67.50 SD: 10.324) was lower than the standard deviation of the control group (M_{cont} : 50.00 SD: 19.263). This indicates that the success of the students in the treatment group was nearer to each other and the students in this group formed a group that is closer to homogeneity in students' success. In the control group, the same homogeneity could not be seen in students' success. Based on the results from the post test, the value of effect size was also calculated. The effect size calculated is 1.31 which shows a large impact of the intervention. According to Cohen (1988), who listed that correlation of 0.5 is large, 0.3 is moderate, and 0.1 is small.

From the analysis of the questionnaire in Section A that was done to identify the interest and perception of students from both treatment and control group. The questionnaire that was conducted to both groups, showed relatively fair amount (40% control group, 55% treatment group) of students who disagree that they could balance chemical equations easily. Both groups also showed less interest in the subject due to finding difficulties in mastering the concept of balancing chemical equation. However, after the conventional method was applied on control group and the method using coloured blocks was applied to the treatment group, 96% of students from the treatment groups found the balancing chemical equations to be much easier and fun. This indicates that the method using coloured blocks to

assist students to balance chemical equations increased the students' interest in the lesson. 95% of students from the treatment group comparing with only 25% student from the control group agreed that they could help their friends understand how to balance chemical equations.

In Section A questionnaire, Item 1, 2 and 5 focuses on asking students if they are able to balance any chemical equations given to them, for this most of the students from both group shows almost similar number of students. About only 23% students agreed and strongly agreed they know how to balance chemical equations. Item 3 and 4 specifically focusing on asking students if they like or they feel balancing chemical equation is fun. Both groups showed 70% students disagree and strongly disagree that balancing chemical equation is fun. Item 8, 9 and 10 focuses more towards the subject of chemistry as a whole and from this both groups also shows 90% of the students like the subject as a whole. This proves that both group are having equal number of students who feel there is no fun in balancing chemical equations. This supports the results of showing the normality of the both groups from the pre-test whereby in terms of interest in balancing chemical equations and chemistry, both groups are equal.

However, after the conventional method was applied on control group and the method using coloured blocks was applied to the treatment group, 96% of students from the treatment groups found the balancing chemical equations to be much easier and fun. This indicates that the method using coloured blocks to assist students to balance chemical equations increased the students' interest in the lesson. 95% of students from the treatment group comparing with only 25% student from the control group agreed that they could help their friends understand how to balance chemical equations.

The questionnaire Section B was assigned to students from the treatment group to identify whether they were able to understand better how to balance chemical equations with the help of coloured blocks and from the results of the questionnaire 95% of students agreed using coloured blocks helps them understand better how to balance chemical equations. 100% of students from the treatment group also agreed that they like using coloured blocks in classroom on how to balance chemical equations and they are able to visualize the coloured blocks when balancing chemical equations without them.

The questionnaire created focused on whether the coloured blocks are able to increase the interest in the concept of balancing chemical equation and also the chemistry subject. From the analysis, it can be seen that in terms of interest in the subject as a whole, most of the students did not show signs of hate or dislike but in terms of understanding and the difficulty in applying the concept is what concerns them.

Teaching and learning session in classroom must incorporate practicing the knowledge and apply them. It has been accepted that learning occurs more permanently by acting and implementing (Ahmet Gurses, 2015). This shows that when students uses visual aids such as coloured blocks, it creates a better understanding and more permanently in their mind. Due to this, the method of using coloured blocks can be a better alternative method of teaching how to balance chemical equation compared to the conventional method. It has been

revealed through recent studies that teaching models and methods aiming conceptual based learning rather than the traditional method develop scientific process skills more. Those skills are necessary for hypothesizing and scientific research (Lavoie, 1999). Apart from that, during the session of using coloured blocks methods to teach to balance chemical equations, it was found that many students had misconceptions on the concept of balancing chemical equations. Nevertheless, these misconceptions was overcome based on the post test results.

The method of using coloured blocks differs from the conventional method in terms of the approach by the teacher. Conventional method is the teacher centred teaching in which teacher explains orally the how to balance the chemical equation or with the aid of the whiteboard and students take notes, follow teachers step and answer given questions. The method of using coloured blocks focuses on students performing hands on activity to stimulate their mind to visualise the atoms and molecules to balance the chemical equations. This method surely makes all the students take part and also responsibility in their learning process. Teachers will play the role of facilitators during the session.

Further research or recommendations on how this technique can be done to improve the lesson in terms the visual aids. The coloured blocks can be labelled with the mostly used atoms and this will make it easier for the students to identify the elements in the compound. This will also help weak science stream students to remember the elements in a compound. Apart from that, the session can be conducted in pairs rather than in groups as when students are paired, both students will equally participate in the session. With this also, teachers will be able to identify which student particularly still having problem in recognising the elements in the compounds.

4. Conclusion

The method of using coloured blocks to teach how to balance chemical equations which was conducted with the treatment group students showed a significant improvement in terms of their post test results compared to the control group students who were taught using the conventional method. Further research can be explored using coloured blocks to grasp other chemistry concept which involved atoms and molecules. Thus, it can be concluded that the method of using coloured blocks has the potential to improve students' concept to balance chemical equations. Teachers should be encouraged to use concrete visual aids to help students visualise chemistry or science content which are abstract. Further studies can be explored in using coloured blocks to help students understand chemistry topics involving molecules such as carbon compounds and their reactions.

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