Effect of Pro-iCo Module towards Students' Achievements on Chemical Bonding

Lai Foong Yip, Nor Hasniza Ibrahim, Johari Surif

Abstract. ***The deterioration of Malaysian students' achievements in Science subject is an alarming issue. Malaysian students' enrolment in STEM at upper secondary schools has gradually declining. Effective STEM teaching materials developed by using appropriate teaching approach for improving students' achievements in STEM field, particularly Chemistry is urgently needed. Thus, the purpose of this study was to determine the effects of the teaching module towards students' achievements on chemical bonding. Pro-iCo Module was designed and developed by the researcher based on STEM-5E learning cycle constructivist approach via ADDIE model. This study used a One-Group Pretest-Posttest Design.. A total of 30 form four Chemistry students were selected purposively from one of the secondary schools in Johor Bahru. The instruments used in this research were (i) Pro-iCo Module Evaluation Questionnaire (Pro-iCo MEQ) (ii) Chemical Bonding Achievement Test (CBAT). Descriptive analysis and inferential analysis (Paired Sample T-test) were used in analysing the data collected. Based on the findings of the Pro-iCo MEQ, the teachers agreed that the Pro-iCo Module has fulfilled all the criteria of evaluation aspects. The findings of CBAT revealed a significant difference (with the value of 22.57) between the mean of pre-test score and the mean of post-test score. The statistical analysis of Paired Sample T-test indicated that students scored significantly higher ($p < 0.05$) in the post-test than in the pre-test. It can be concluded that the implementation of Pro-iCo Module has significant positive impact on students achievements in chemical bonding. Hence, Pro-iCo Module could be used as an appropriate teaching module by teachers in implementing STEM approach at schools for enhancing students' achievement in chemistry.***

Keywords: teaching module; chemical bonding concepts; STEM-5E Learning Cycle

I. INTRODUCTION

The deterioration of Malaysian students' achievements in Science subject is an alarming issue [1]. Based on the report of Malaysia Education Blueprint 2013 – 2025, the results of TIMMS Science scores fell below the international average, with the value of 471 (21st out of 48 countries), and 20% of Malaysian students did not achieve the minimum benchmarks of Science scores in 2007, a two- to fourfold rise since 2003 [2]. The report stated that students' poor achievement in TIMMS Science score was due to their inability to apply the scientific knowledge in solving problems although they seemed to understand the basic Science concepts. Students' poor achievement in Science affect their interests and confidence level which results in a decline in students' enrolment in STEM at upper secondary schools [3].

In the curriculum of Malaysia, chemistry is an elective subject of STEM field at the upper secondary level. Chemistry which is one of the most important subjects of STEM field has been viewed by many researches as a difficult subject for students[4]–[6]. Furthermore, research studies have proved that many chemistry concepts are very difficult to learn and understand by most students [7]–[10]

The difficulties in learning chemistry concepts may have greatly lowered the interest and confidence of many students. Hence, chemistry which is supposed to be a fascinating field of study is raising a serious treat to many students today, a number of students have already developed phobia towards chemistry learning as a result of their constant low performance on assessment or repetitive disappointment in external examinations [10, 43].

"Chemical Bonds" is listed as the learning area four under the theme of matter around us in the Integrated Curriculum for Secondary Schools : Curriculum Specification Chemistry Form 4 by [11]. This chemistry topic explains about the formation of ionic and covalent compounds through chemical bonding.

[12] highlight that some of the errors often performed by students in answering the questions of Malaysian Certificate of Education (Sijil Pelajaran Malaysia) (SPM) level include failure to write the electron arrangement of ionic bonds and covalent bonds formed, unable to draw electron arrangement diagram to show the formation of ionic bonds and covalent bonds as well as creating a mental picture about the formation of this bond. In addition, students are still confused to differentiate ionic bonds and covalent bonds.

Effective pedagogical approach facilitates students' conceptual understanding and improve their performance in science learning. The successful of a science lesson requires the careful instructional design that brings about conceptual growth in students. However, most of the teachers still prefer to use teacher-centred methods to teach chemistry [13]. The use of traditional teaching methods may cause students in acquiring only core knowledge instead of mastering 21st century skills that would allow them to be successful in the workforce [14]. Additionally, traditional teaching also lack of interactive and engaging activities. The science lessons in a traditional classroom is dull and boring, thus declining students' interest and curiosity in learning the scientific concepts.

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Why teachers need to integrate STEM-5E Learning Cycle in chemistry lesson? STEM-5E Learning Cycle inspires students to develop into independent problem solvers and nurtures students' understanding across different subject areas because they are provided with opportunities to work in cooperative learning groups on meaningful activities that are related to real-world problems [15, 42] The research study of [16] indicates that STEM programs that involve hands-on, active students' engagement and relevant to the real world situations can be helpful in enhancing students' positive interest in STEM content and careers.

Traditional teaching is difficult to develop conceptual understanding of chemical concepts. According to[15], a well-designed STEM-5E Learning Cycle is naturally interdisciplinary and collaborative, thus it is perfectly appropriate for developing students' conceptual understanding since integration of different disciplines and involvement of students in socially-interactive learning promotes conceptual understanding of concepts. Additionally, STEM-5E Learning Cycle provides students with opportunities to collaboratively develop and use model to solve real life problems related to the chemistry concepts. The construction of creative and innovative analogical model by students themselves helps them to generate concrete item in macroscopic level for learning the abstract concepts. The use of analogical models is an attractive way to visualize abstract science concepts because it stimulates the curiosity and imagination of students and boosts their creative thinking [17].

Chemistry teachers need to apply up-to-date teaching methods that promote STEM practice in chemistry instruction. This is an essential effort to enhance students' skills, knowledge and values that enable them to thrive and compete in the STEM field at global level.

II. Statement of Problem

Chemistry as an abstract field of study requires students to understand its content by using their formal operational thought. However, most students can operate only on the concrete operational level and lack of the abilities to shift between the three levels of thought : macroscopic, microscopic and symbolic levels in chemistry and are more prone to overload their working space memory when learning difficult chemistry topics [4].

Chemical bonding is widely known as a critical concept for chemists and is crucial for the understanding of chemistry [18]. Nevertheless, many studies in chemistry education have explained various difficulties of students in learning chemical bonding concepts[18]. The microscopic level and abstract nature of the chemical bonding concepts lead to many difficulties in learning this concepts [19], [20] Students cannot see the microscopic level of chemical entities, for instance atoms, atomic structures and the chemical interactions among atoms because chemical bonding consists of the abstract matter and distant from everyday experience[4].

[18]point out that students' difficulties in learning chemical bonding include the difficulty in understanding why chemical bonding happen, the failure to explain the chemical bonding phenomena correctly and their confusion regarding covalent bonding and ionic bonding.

Since the students' learning difficulties in chemical bonding impede the teaching and learning process of chemistry and result in students' low achievement in chemistry, researchers should strive hard in helping students to remove the roadblock of the chemistry learning. Majority of the studies only focus on the issue of students' misconceptions of chemical bonding and their difficulties in learning chemical bonds. On the other hand, STEM education is newly implemented in Malaysia education system in the year of 2017, there is a limited number of researches to study the effectiveness of appropriate instructional design to enhance students' conceptual understanding of chemical bonding concepts. Besides, there is also a lack of research aiming on specific approaches of integrated STEM education[21]. One of the greatest challenges for Malaysian science education is the insufficient guidelines or models for science educators to apply STEM approaches in the classroom in a correct way [22]. Therefore, there is a pressing need to study and design an effective teaching plan to create a STEM-5E Learning Cycle environment that can help teachers to improve students' performance in learning chemical bonding.

In this study, a STEM teaching module was developed based on the 5E learning cycle: engagement, exploration, explanation, elaboration, evaluation. The study of[23] suggested that teaching materials developed via 5E learning cycle can provide students with the opportunities to apply critical thinking skills by learning their own concepts, enable them to link new knowledge to their cognitive structure and constructing meaningful learning process. [24] points out that the used of teaching materials developed using STEM-5E learning cycle could improve students' learning outcomes in chemistry. In addition, some of the previous studies [24]–[32] recommended that the 5E learning cycle based on the constructivist approach is an appropriate instructional approach in chemistry teaching because it is more effective in enhancing students' learning performance in chemistry.

III. Research objectives

This study aims to determine the effects of Pro-iCo Module based on a pedagogical strategy using STEM-5E Learning Cycle towards students' learning of chemical bonding concepts. The objectives of this research are as the following :

1) To develop a teaching module for the chemical bonding topic based on STEM-5E Learning Cycle.
2) To examine the effectiveness of the Pro-iCo Module on the students' achievements of chemical bonding before and after the intervention.

IV. Research questions

The following are the research questions of this research :

1) How to design and develop the chemical bonding teaching module?
2) Does Pro-iCo Module has effect towards students' achievements in chemical bonding?

V. METHODOLOGY

A. Research Design

The research design for this research includes two main methodologies: (1) methodology for the development of Pro-iCo Module and (2) methodology for the measurement of the effectiveness of Pro-iCo Module towards students' achievements.

The research methodology for the design and development of Pro-iCo Module was the ADDIE Instructional Design Model. The ADDIE Instructional Design Model was proposed by Rossett in the year of 1987. This model provides a structured and systematic process. It is a convenient model for a novice designer in developing teaching module. ADDIE model has a framework with five phases : Analysis, Design, Development, Implementation, and Evaluation.

A quantitative One Group Pretest-Posttest Design (O_1 X O_2), which is one of the Pre-experimental Design [33] was used in examining the effectiveness of the Pro-iCo Module towards students' achievements on Chemical Bonding. A pretest and posttest design is employed to evaluate the effect of changes in an educational environment such as the introduction of a new teaching approach by comparing the levels of performance before the introduction of a new teaching approach to levels of performance after the introduction of the new teaching approach [34].

Based on this type of design, a pre-test and post-test were administered to the same sample before and after the implementation of Pro-iCo Module, measuring the dependent variable (achievement) both before and after exposure to the independent variable (module intervention). The research design used in this research is represented in the FIGURE 1. In this research design, students were administered with a pre-test measure (O_1) followed by an intervention using Pro-iCo Module (X) and a post-test measure (O_2).

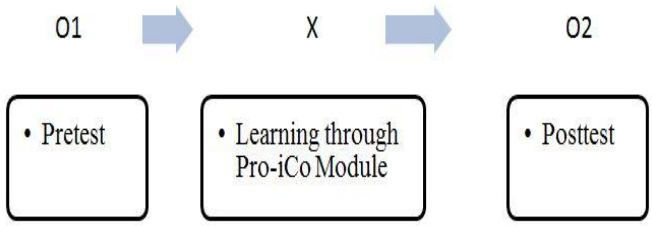

FIGURE 1 : Non-equivalent (Pretest and Posttest) Control-Group Design

B. Research Procedure

This research procedure consists of four stages as illustrated FIGURE 2. The description of each stage of the research procedure is explained in this section.

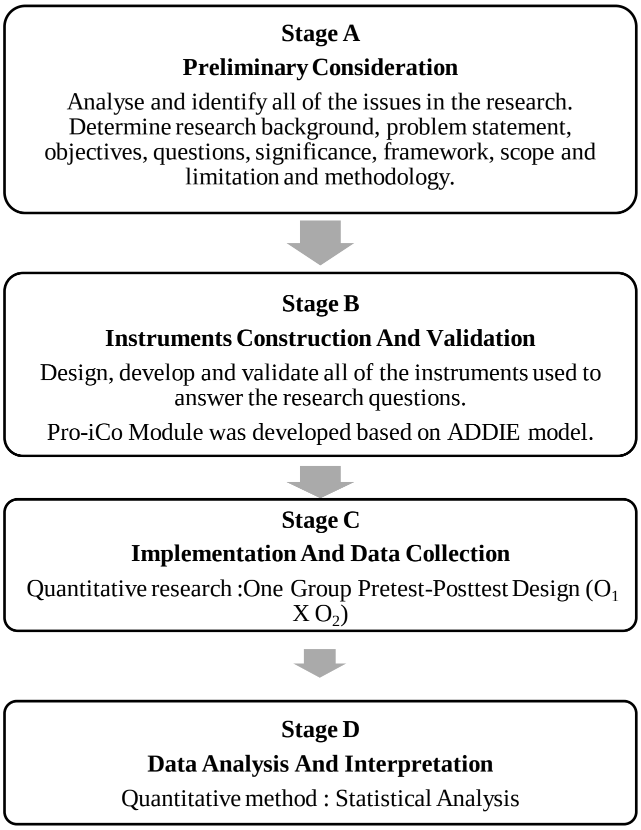

FIGURE 2 : Research procedure

C. Research Population and Sample

The main population of this study consists of Form four Chemistry students from all secondary schools in Johor Bahru. The research sample for answering research question 2 : *Does Pro-iCo Module has effect towards students' achievements in chemical bonding?* consists of 30 form four Chemistry students. According to [35], a sample with 30 respondents will normally provide results comparable to a normal distribution. These students were selected by using purposive sampling technique, where students were selected from the members of the population based on certain consideration.. The purpose of purposive sampling technique is to acquire a sample of population who meet certain predetermined criterion [36]. The sample of this research came from one of the secondary schools in Johor Bahru. They were form four students who have selected Chemistry as their elective subject.

The other population of this research is the chemistry teachers from all secondary schools in Johor Bahru. 38 chemistry teachers who are teaching in Johor Bahru were randomly selected via random sampling technique in answering the questionnaire for research question 1 : *How to design and develop the chemical bonding teaching module?*

D. Research Instrument

The research instruments used in this study are Pro-iCo Module Evaluation Questionnaires and Pre/Post Chemical Bonding Achievement Test (CBAT).

Pro-iCo Module Evaluation Questionnaires

Pro-iCo Module Evaluation Questionnaire (Pro-iCo MEQ) is a questionnaire developed by researcher to identify the perspective of teachers about the effectiveness and appropriateness of using Pro-iCo Module as a teaching guide for enhancing students' conceptual learning of chemical bonding concepts. It is important to seek the teachers' views, comments and suggestions to review and improve the quality of the module. Some of the questionnaire items are adapted from[15]. The content of the instrument is checked and verified by experts. The Pro-iCo MEQ has a total of 35 closed-ended Five-Likert Scale quantitative items that are scaled 1-5 in which 1 is "strongly disagree" and 5 is "strongly agree". Respondents are required to answer all of the questions in the questionnaire. The questionnaires are distributed to respondents personally or by using internet google survey form.

Pre and Post Chemical Bonding Achievement Test

Pre and Post Chemical Bonding Achievement Test (Pre and Post CBAT) were developed by the researcher for measuring and comparing students' achievement on chemical bonding concepts before and after the implementation of a Pro-iCo Module intervention.

The achievement tests were developed by researcher based on the Specification Chemistry form four of Integrated Curriculum for Secondary Schools (KBSM). The tests focus on the six levels cognitive domain of Bloom's Revised Taxonomy, with difficulty levels from low to high. The Chemical Bond Achievement Tests consists of four structured questions about chemical bonding concepts. The content validity of the tests were checked and verified by chemistry experts. Students were required to answer all the questions within 60 minutes. Both Pre-CBAT and Post-CBAT consist of the same items but differ in number ordering to avoid recognition.

VI. DESIGN AND DEVELOPMENT OF PRO-ICO MODULE

One of the main objectives of this research is to design and develop an effective teaching module on the topic of chemical bonding. The development of a teaching module requires the use of the systematic Instructional Design Model and implementation of an appropriate learning theory. The ADDIE Instructional Design Model developed by[37], which involves the five phases (*Analyse, Design, Develop, Implement and Evaluate*) was used in constructing the teaching module. Additionally, STEM-5E Learning Cycle that based on the constructivist learning theory was implemented in the design and development of the teaching module.

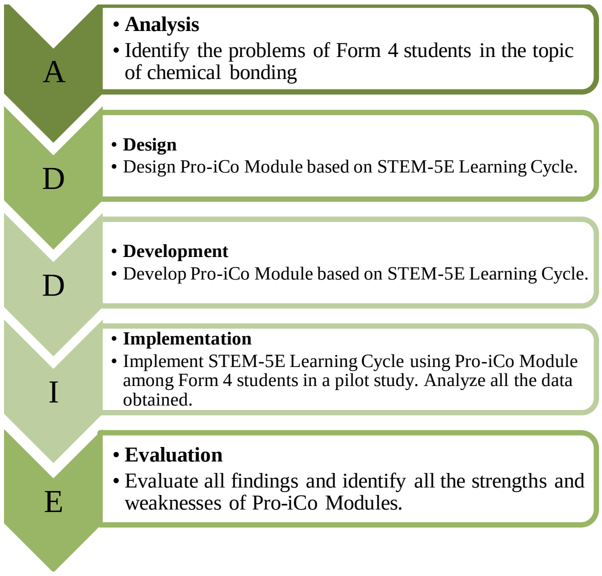

FIGURE 3 : Module development via ADDIE Model [37]

VII. ANALYSIS PHASE

Analyse phase is the initial phase of ADDIE model, which is essential for identifying the possible origins for a performance gap [38]. According to[38], the main components of analyse phase are performance assessment, purpose statement, list of instructional goals, learner analysis, required resources, potential delivery systems (with cost estimations) and project management plan. The lack of knowledge and skills among the students is one of the main possible cause of the performance gap. Furthermore, another origins of the performance gap is the lack of resources such as teaching module. In order to close the performance gap of chemical bonding, there is a need to develop a teaching module that provides the effective teaching and learning guidance and materials for teachers to improve students' performances in chemical bonding.

VIII. DESIGN PHASE

Design phase was an important phase to validate the desired performances and proper testing approaches by preparing a set of functional specifications for closing the performance gap caused by a lack of knowledge and skills [38]. In this phase, the learning objectives, instructional strategy and assessment instruments were designed according to the instructional goals of the module. At the end of the STEM-5E Learning Cycle teaching and learning activities, students are able to achieve the following learning objectives:

1) Relate and apply the chemical bonding concepts in real world context.
2) Solve real world problems related to chemical bonding concepts using STEM-5E Learning Cycle
3) Build analogical model of ionic and covalent compound to visualize the formation of ionic and covalent bonds.
4) Communicate and present their conceptual understanding of chemical bonding concepts correctly. data analysis

After determining the pedagogical approach used to overcome students' learning difficulty, the module was designed based on the selected

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pedagogical approach. Pro-iCo Module was designed according the teaching and learning of STEM-5E Learning Cycle. The 5E Instructional Model proposed by [39] was used as the teaching and learning cycle in designing the teaching and learning process in a more systematic and effective way. On the other hand, testing strategies were generated to identify the appropriate assessment instruments used in implementation and evaluation phases.

IX. DEVELOPMENT PHASE

The intention of the Development phase is to construct and validate the instructional materials [38]. The Pro-iCo Module was developed systematically through stages after designing the learning objectives, assessment instruments and instructional strategy. Development phase refers to the construction and preparation all of the instructional materials, which also include the composing of the module's content, with the detail description of the pedagogical approach applied and lesson plan. Content is the crucial part for engaging the student throughout the activity of knowledge construction [38]. The content of the module developed was aligned with the syllabus of form four chemistry and well-organized according to the pedagogical approach, which is the STEM-5E Learning Cycle approach. The comprehensive instructional guidance for teacher and student were developed systematically according to the flow of student learning activities in STEM-5E Learning Cycle as shown in FIGURE 4.

Pro-iCo Module was developed systematically. In addition, a pilot study was conducted in one of the secondary school in Johor Bharu. The process of reviewing and revising the module according to the feedback given are important steps for ensuring the achievement of the learning objectives. In the end of development phase, the final product was produced in the form of CD-ROM and printed material.

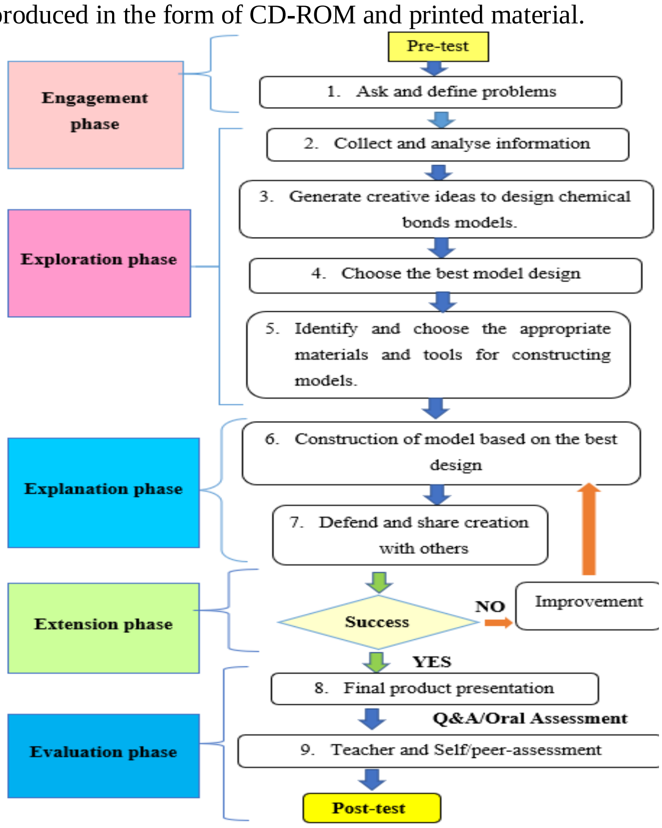

FIGURE 4 : The flow of student learning activities in STEM-5E Learning Cycle.

X. IMPLEMENTATION PHASE

The implementation phase was carried out after the Pro-iCo Module was created in the development phase. The effectiveness of the module in the teaching and learning of chemical bonding concepts was pilot-tested among Form 4 students in one of the secondary schools in Johor Bharu. The problems arose during the implementation of the instructional materials were identified. All findings collected are analysed to identify the weaknesses and strengths of the modules. Improvement would be made to ensure the validity and quality of the Pro-iCo Module.

XI. EVALUATION PHASE

Evaluation phase is an important phase to determine the effectiveness of the instructional materials in attaining the instructional goals and objectives. According to [38], this phase aims to evaluate the quality of the teaching resources before and after implementation the instructional product. Summative assessment was conducted when the final product was created and ready to be assessed through questionnaire and the expert reviews. Pro-iCo Module developed in this research was validated by experts in the field of chemistry education, which include lecturers and chemistry teachers.

Findings on The Evaluation of Pro-iCo Module

The data collected through the Pro-iCo Module Evaluation Questionnaire (Pro-iCo MEQ) instrument were analysed using descriptive statistics through the application of Statistical Package for the Social Science (SPSS) version 22 software. A total of 70 questionnaires were distributed to teachers via google online forms. Nevertheless, merely 38 questionnaires were returned to the researcher. Hence, the rate of response is at 54.29%. Cronbach's alpha value was used to measure the reliability of Pro-iCo MEQ in this study. The Cronbach's alpha value of the 35 items in Pro-iCo MEQ was 0.984 (value $\alpha > 0.70$), which indicates a high reliability of the instrument.

FIGURE 5 shows the average mean values rated by teachers on the four evaluation aspects of the Pro-iCo Module. Overall, teachers gave good ratings for the four aspects of evaluation, with the average mean values of above 4.00. Among the four aspects of evaluation, the aspect of content (mean = 4.36) has the highest average mean value, whereas the aspect of assessment (mean = 4.27) has the lowest average mean value. As a conclusion, the findings show that teachers very agreed that the Pro-iCo Module has fulfilled the criteria of an effective teaching and learning module based on the four aspects of module evaluation.

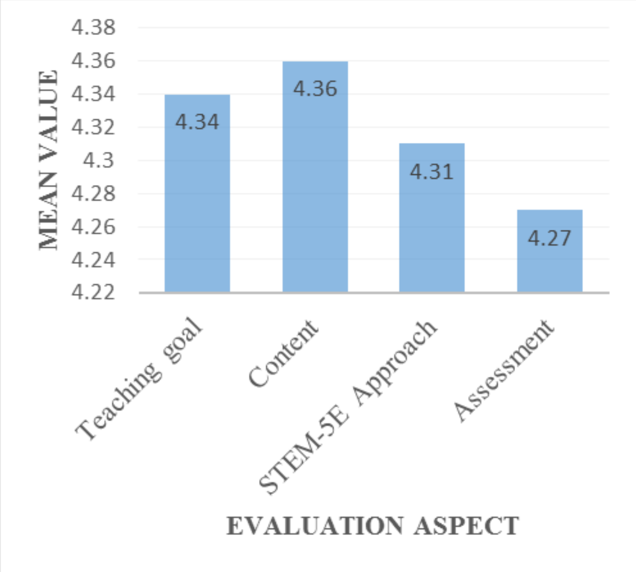

FIGURE 5 : Average mean for the evaluation aspects of the Pro-iCo Module

XII. RESULT AND FINDINGS

A. Descriptive Analysis

Measures of central tendency and dispersion were computed to summarize and compare the data for the overall differences in the pre and post CBAT. TABLE (1) shows the summary of the detailed descriptive statistics in the pre and post tests.

TABLE 1 : Descriptive statistics comparison for overall differences in the pre and post CBAT

Type of Test	N	Min	Max	Mean	Std. Deviation
Pre-CBAT	30	5.00	75.00	38.1667	18.58639
Post CBAT	30	18.00	86.00	60.7333	15.99986

The low mean scores of Pre-CBAT (M = 38.17 ; SD = 18.59) revealed that students were weak in Chemical Bonding topic before using Pro-iCo Module in the teaching and learning of Chemical Bonding. After the intervention, the mean score value for students in the Post- CBAT (M = 60.73 ; SD = 16.00) was higher than that in Pre-CBAT. Hence, there was a difference between the mean scores of Pre and Post-CBAT, with the value of 22.57. Additionally, the data showed a difference between the minimum scores and maximum scores of Pre and Post-CBAT, with the improvement value of 15 and 11 respectively.

Scores from the Pre-CBAT and Post-CBAT are recorded as shown in FIGURE 6. The data revealed that all of the students presented a positive achievement in their post CBAT after learning Chemical Bonding using Pro-iCo Module. Based on the comparison of students' achievement scores in the Pre and Post-CBAT, majority of the students managed to obtain an increment of scores with the value of more than 10 marks. S4, S11, S18, S24, S26, S28 and S30 are the 7 students who achieved an increment of scores with the value of 35 marks and above. S11 and S18 obtained the top increment of scores, with the value of 47 marks. On the other hand, there were two students (S25 and S29) who obtained the lowest increment of scores, with the value of 4 marks. Overall, all of the students achieved a greater performance in their Post-CBAT in learning Chemical Bonding via Pro-iCo Module and none of them exhibited a decline in their performance. Hence, Pro-iCo module had a positive effect on students' achievements in learning Chemical Bonding.

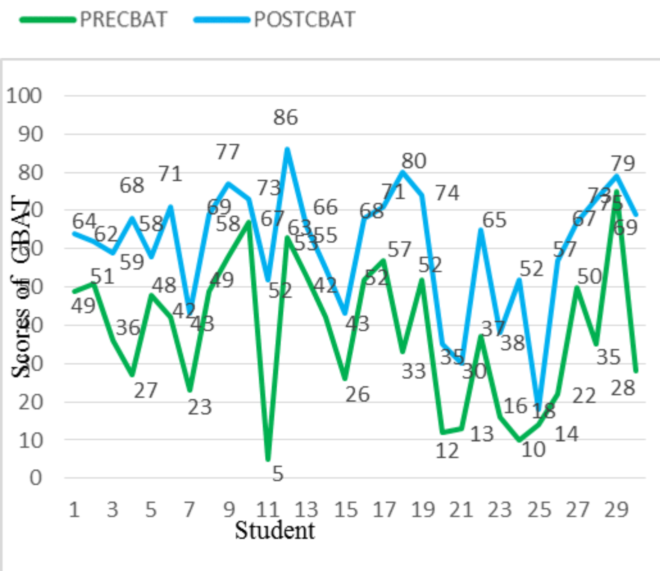

FIGURE 6: Comparison of students' achievement scores in the pre and post CBAT

These findings are aligned with a number of previous studies [25], [26], [28]–[32], which revealed that learning cycle model grounded on the constructivist teaching approach has a positive impact on students' academic achievement.

Paired Sample T-test

The Paired Samples T-Test was used to compare the scores of the two groups. This test was run with the following hypotheses:

a) Null hypothesis, H_0: There is no significant difference between the mean of Pre-CBAT scores and the mean of Post-CBAT scores.
b) Alternative hypothesis, H_1: There is a significant difference between mean of Pre-CBAT scores and the mean of Post-CBAT scores.

TABLE (2) gives the values of the correlation between Pre-CBAT and Post-CBAT. This means that the Pre-CBAT scores have a significant difference from the Post-CBAT scores (r = 0.753, p = 0.000).

TABLE 2 : Paired Samples Correlations for the Pre-CBAT and Post-CBAT

		N	Correlation	Sig.
Pair 1	Pre-CBAT & Post-CBAT	30	.753	.000

TABLE (3) shows the mean for Paired T-test is 22.5667

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and standard deviation 12.3838. The significant value, 0.000, is lower than the value of alpha, 0.05, thus rejecting the null hypothesis. This means that the mean of Pre-CBAT scores have a significant difference from the mean of Post-CBAT scores (t (29)= -9.981, p = 0.000). These results suggest that there is improvement in students' Post-CBAT scores after learning by using Pro-iCo Module. As a conclusion, there was a significant difference between the mean of Pre-CBAT scores and the mean of Post-CBAT scores.

TABLE 3 : Paired Sample Test Statistics of the Pre-CBAT and Post-CBAT

	Paired Differences					T	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 Pre-CBAT – Post-CBAT	-22.5667	12.383758	2.26096	-27.1908	-17.9425	-9.981	29	0.000

Effect size

The effect size measured using Cohen's d in this study was 1.31 , considered to be very large according to Cohen's criteria. The classification of Cohen's effect sizes are : small (d = 0.2), medium (d = 0.5), large (d = 0.8) and very large (d = 1.3) [40]. The value of Cohen's d indicates that there was a very significant difference between the means of the two tests.

XIII. DISCUSSION

The students' post-test scores (mean score=60.73) were greater than the pre-test scores (mean score=38.16). The statistical analysis of *Paired Sample T-test* indicated that students scored significantly higher (t = -9.981; $p < 0.05$) in the post-test than in the pre-test. There was a significant difference (with the value of 22.57) between the mean of pre-test score and the mean of post-test score for the Chemical Bonding Achievement Test (CBAT). All of the students demonstrated a positive improvement in their post-test scores as compared to their pre-test scores. This overall improvement has proved that the implementation of Pro-iCo Module has significant positive effect towards students' achievements in Chemical Bonding.

This finding is in line with the findings in the study of[24], which showed the significant effect of using teaching materials based on STEM-5E learning cycle to enhance students' performance in Chemistry. This is because the application of STEM-5E learning cycle approach, which is an innovative constructivist approach that emphasizes on student-centred learning encouraged students to construct scientific knowledge through meaningful learning. Teacher acted as a facilitator that facilitated the development of Chemistry concepts during the lesson.

The research findings of[23, 44] stress the need to develop teaching resources based on 5E Learning Cycle approach : engagement, exploration, explanation, elaboration, evaluation. According to them, 5E Learning Cycle approach provides chances for students to practice critical thinking skills by discovering their own concepts and allows students to link new information with their cognitive structure as well as constructing meaningful learning process. Additionally, the study of [24] stressed that STEM-5E learning cycle is an effective approach for enhancing students' concept mastery, as the students learning experience are in harmony with the cognitive development stage of students that is formal operational stage.

In addition, the implementation of Pro-iCo Module provided students the opportunity to carry out hands-on activity for improving their achievements in Chemical Bonding. During the implementation of the STEM-5E learning cycle, students were exposed to hands-on activities that helped them to visualise the abstract concept using concrete Chemical Bonding models developed by themselves. The study of [41] has proved that hands-on activities enable students to show positive attitudes towards Chemical Bonding learning and achieve better in Chemical Bonding. His study highlights the advantages of learning through hands-on activities. Hands-on activity helped to make his lesson more interesting, involved students to interact with others, developed their confidence, allowed them to practice critical thinking and improved their cognitive skills, which brought about positive motivational effects.

Moreover, Pro-iCo Module also provided students the opportunity to solve real life problems using Chemical Bonding concepts. One of the STEM teaching and learning activities required students to investigate and explore to identify real-world problems The minds-on activity allowed students to practice their higher order thinking skills and critical thinking skills. The improvement of their cognitive thinking level helped them to achieve better result in the Chemical Bonding Achievement Test (CBAT) because CBAT was made up of 86% higher order thinking skills questions.

Furthermore, the meta analysis study of [25] revealed that 5E Learning cycle approach is more effective in enhancing students' academic achievement, learning attitude and science process skills as compared to the traditional way of teaching. According to his findings based on the analysis of 31 quantitative experimental studies between the year of 2006 to 2016, 5E Learning Cycle approach was found to be a very efficient teaching model for enhancing academic achievement than the traditional teaching approach.

As a conclusion, the findings obtained from the analysis result of Pre-CBAT and Post-CBAT scores supports that Pro-iCo Module, which was designed and developed based on STEM-5E learning cycle constructivist approach, helped to enhance students' achievement in Chemical Bonding. Hence, Chemistry teachers are encouraged to adopt and adapt the teaching and learning activities of Pro-iCo Module into their Chemistry teaching for creating a more meaningful constructivist learning environment to enhance students' achievements in Chemistry, specifically Chemical Bonding topic.

XIV. IMPLICATION

The findings and discussions of this study indicate the positive effects of Pro-iCo Module towards students' learning in chemical bonding topic. The findings of the development and implementation of Pro-iCo Module based on STEM-5E learning cycle concerning chemical bonding topic have important implications for Education Ministry of Malaysia, teachers and students.

Firsty, the activities provided in Pro-iCo Module can be adapted and revised to fit into the chemistry textbook because the current chemistry text book is not up-to-date to the STEM approach. The findings of this study provide information for the Curriculum Development Centre of Malaysia in reviewing the textbook and other curricular materials to improve the quality of chemistry education.

Besides, the ministry of education can develop Continuing Professional Development (CPD) programmes in STEM education by using the revised Pro-iCo Module to expand and deepen chemistry teachers' pedagogical knowledge and skills in STEM education. Pro-iCo Module provides a medium for chemistry teachers in developing a deeper understanding of STEM teaching model in teaching and learning of chemical bonding concepts.

Additionally, teachers can use the Pro-iCo Module to integrate STEM-5E Learning Cycle in teaching and learning of chemical bonding concepts into their classrooms. Moreover, teachers can also adapt the learning activities in the Pro-iCo Module for the co-curricular activity of the Science Society such as Science Carnival to attract students' interests in learning STEM subjects and enhance their STEM knowledge and skills.

The STEM-5E learning environment allows students to relate and apply the chemical bonding concepts to solve real world problems related to chemical bonding concepts by building analogical model of ionic and covalent compound to visualize the formation of ionic and covalent bonds. Furthermore, students are encouraged to communicate and present their conceptual understanding of chemical bonding concepts correctly

XV. RECOMMENDATION

Some recommendations for future study are as the following :

i. The teaching module developed only comprised one of the chemistry topics, which is the chemical bonding. Hence, future research to develop STEM teaching module containing more chemistry topics is suggested.
ii. Before conducting the intervention, researcher should provide proper training regarding the theoretical knowledge and effective skills on the pedagogical approach used in the developed module for teachers involved in the study. The researcher should also provide a comprehensive briefing on the implementation of the teaching model to the students involved in the study before conducting the research.

XVI. CONCLUSION

The teaching and learning process using Pro-iCo Modules through STEM-5E learning cycle in this study helped to create a constructivist learning environment that could enhance the students conceptual learning in Chemical Bonding. This is in line with the study of [29], which reported that the constructivist teaching approach is more effective than the traditional approach in improving students' achievement in Chemistry. The findings of this study suggested that the STEM-5E learning cycle constructivist approach could be employed in developing teaching module for other Chemistry topics. This is supported by the study of [24], which the researchers proved that instructional materials developed by using STEM-5E learning cycle approach is effective and appropriate to be implemented in classroom because the teaching model can enhance student' concept mastery and helps to improve students' performance in Chemistry learning. The findings of this study revealed that the implementation of Pro-iCo Module has significant positive impact on students achievements in chemical bonding. Hence, Pro-iCo Module is an appropriate teaching module and could be used by teachers in implementing STEM approach at schools for enhancing students' achievement in chemistry.

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