CHEM-A MODULE BASED ON STEM APPROACH IN CHEMICAL BOND

Nur Adilah Abdol Samat, Nor Hasniza Ibrahim, Johari Surif, Marlina Ali, Abdul Halim Abdullah, Corrienna Abdul Talib and Muhammad Abdul Hadi Bunyamin

Abstract:*The aim of this research is to develop a Chem-A Module based on STEM approach in Chemical Bond topic. This is based on previous studies found that there have problems of Chemical Bond topic among students and conventional teaching strategies that are less beneficial to the students. Therefore, the researcher convince that it is required to find other initiatives in enhancing the understanding of students in this topic by using teaching strategies based on the STEM approach. It is allign with Malaysia's Education Development Plan (2013-2025) who wish to apply STEM as a new learning approach to increase students' interest and provide them with the challenges of this changing world. In addition to the STEM approach, this module applies lesson planning through problem-based learning and problems are given in the form of scenarios. The objective of this research was to look at the effectiveness of the module among the students on the Chemical Bond topic and to see the teacher's perspective toward this module. The entire design of this research is quantitatively in the form of pre experimentation based on one group. Sample selection was determined based on a purposive sampling method, which is 30 students were selected as the sample of the study. This study was initiated with pre-test implementation, followed by Chem-A Module exposures and ended with post-test. Furthermore, pre-test and post test were analyzed descriptively using SPSS software to obtain pre-test mean value and post-test mean value and then t-test was used to identify whether there was significant difference between pre-test and post-test among students. In addition, in looking at the teacher's perspective on this module, the questionnaire was distributed to 10 teachers and the findings were analyzed using SPSS software to obtain the frequency and percentage values for each item. Overall, the findings show that Chem-A Modules can enhance students' understanding in Chemical Bond topic. This is proven by increased marks in post-test compared to pre-test and there is a significant difference between pre-test and post-test. The findings also found that most teachers gave positive feedback on this module. In conclusion, this Chem-A Module shows good effect in terms of understanding students in the Chemical Bond topic and the teacher's perspective on this module.***

Index terms:*Chem-A module, Chemical Bond, STEM education, problem based learning*

Revised Manuscript Received on December 22, 2018

Nur Adilah Abdol Samat,Utama International School, No. 16B, Jalan Rhu, Melodies Garden, Johor.

Nor Hasniza Ibrahim, School of Education, Faculty of Social Science and **Humanities**, University Teknologi Malaysia,

Johari Surif, School of Education, Faculty of Social Science and Humanities, University Teknologi Malaysia,

Marlina Ali, School of Education, Faculty of Social Science and Humanities, University Teknologi Malaysia,

Abdul Halim Abdullah, School of Education, Faculty of Social Science and Humanities, University Teknologi Malaysia,

Corrienna Abdul Talib, School of Education, Faculty of Social Science and Humanities, University Teknologi Malaysia,

Muhammad Abdul Hadi Bunyamin, School of Education, Faculty of Social Science and Humanities, University Teknologi Malaysia, 81310 UTM Skudai, Johor,nuradilahabdsamat@gmail.com

I. INTRODUCTION

Today, science and technology are growing rapidly, and have a great impact on human life. Thus, science and technology education is very important and should be used as a compulsory element in the education system. This is to provide the young people today to play their part as a community that can give contribution to the country. According to the Malaysian Education Development Blueprint (to achieve skilled manpower in science and technology, in 1967, the National Education Policy has targeted the percentage of students in science and technology stream compared to art stream were at 60:40 by 2020. However, as of 2012, the participation of students in the science stream has not reached 60% and thus, there is a worrying decline Because of that, according to Tami et al., most students argue that chemistry is a difficult subject and this difficulty can be seen in some contexts where students need to develop chemical concepts and problem solving skills. Therefore, teachers need to play an important role in finding effective teaching strategies to improve students' achievement in science education especially for Chemistry subjects. Hence, this study develops teaching and learning modules in the topic of the Chemical Bond using the STEM approach. The teaching strategy based on the STEM approach is in line with the Malaysia Education Blueprint (2013-2025) that wishes to apply STEM as a new learning approach to provide students with the challenges of the changing world. In addition to the STEM approach, this module applies lesson planning through problem-based learning and problems are given in the form of scenarios. The application of this teaching strategy is also in line with the 21st century learning that wants to transform a teacher-centered learning approach to student-centered learning. The main objective of this study is to look at the effectiveness of the Chem-A Module among students on the topic of the Chemical Bond in terms of understanding and to see the teacher's perspective on this module.

II.PROBLEM' BACKGROUND

states that Chemistry subject is one of the most important and difficult subject and have been acknowledged by teachers and researchers.

There are various factors that lead to most students who think Chemistry is difficult to master. Among the factors identified are the problems of students in mastering the topics of the Chemical Bond and the traditional methods of teaching today. Many of the previous studies relate the problems of students in this topic [12]-[20].

A study by Nimmermark that examines the misconception problems of Swedish and South African students on the topic of the Chemical Bond found that only 55 to 60% of students from different levels of students state that potassium chloride exists in molecular form. His entire study result summarizes only 20% of the first year students of the university who are fully aware of this chemical bond topic[21].

In addition, the teacher's teaching strategy affects the learning process of the students and thus in the students' understanding of the science concepts. The attitude of the teacher who uses the traditional method is the cause of the difficulty in realizing the teaching process and learning more meaningful. This is because traditional teaching is a teacher-centered and causes students to be passive in which students are not directly involved in the learning process in the classroom. In other words, teachers as educator and students as mere listeners. Hence, this teaching method fails to motivate students to continue learning in chemistry . Not only that, this method will cause students to continue with their existing concepts as there is no two-way communication between teachers and students. However, teachers still use teacher-centered teaching methods in teaching and learning . According to Nurshamshida et al the method only focuses on mastery of content with less emphasis on the development of scientific skills and attitudes. It is supported by Jesse et astate that it will give the less opportunity for students to take on the role in the classroom and thus the student participation in the lesson will become restricted[1]-[11].

Hence, in this study, an approach to addressing the problems of student difficulties in understanding the Chemical Bond topic will be implemented. Chemical Bond are among the subjects of Form 4 Chemistry and the theme for this topic is matter around us. On the basis of concern to the students' perceptions of understanding the concept of chemical bonds, a learning module has been developed. The purpose of this module is to look at the effectiveness of the teaching and learning process using the STEM approach. The STEM approach is focused on chemistry courses required for most students across science, technology, engineering and math (STEM). In addition, according to Chonkaew et al., high demand in most countries today is on decent researchers and technicians in which they are able to identify, adapt and use knowledge in science and technology more significantly in developing a unique technology. However, most countries across the globe experience a small number of learners to study STEM knowledge even in the United States and European countries Not only that, the interests, motivations, beliefs, attitudes, and student's self-esteem towards science and technology have also declined Therefore, the module using this STEM approach involves students actively to stimulate their understanding and interest in learning activities especially in understanding the concept of Chemical Bond.

In addition, to improve the effectiveness of the module, the STEM approach is applied through problem-based learning and the problems are in the form of scenarios. This learning is a student-centered approach which according to Senocak et al., it encompasses most of the possibilities to improve learning, as students become more active and cooperate with each other, provide rapid feedback and improve student accountability . It is also supported by which states that from focusing solely on facts, problem-based learning can promote active and self-directed learning based on the context of real-life situations.

Hence, this study implements a module of teaching called the Chem-A Module specifically for the topic of the Chemical Bond. This module applied the teaching strategies of STEM approaches through problem-based learning and problems are given in the context of the scenario. This module is applied to students to see their effectiveness in the topic of the Chemical Bond and also identify teachers' perceptions of this module[23]-[25].

III. THEOROTICAL FRAMEWORK

This study is based on constructivism theory. This theory has different perspectives. According to Kyere constructivism refers to a concept that describes the learning experience and how one builds knowledge based on what has been learned. Jones and BraderAraje point out that constructivism has a huge impact on the teaching and design of the curriculum as it is found to be effective in the current educational approach. In addition, Piaget focuses on the active role of the individual in learning because according to him, all knowledge is bound to action and knows something is to adapt it in the scheme of action.) considers constructivism as an epistemology in which individuals gain knowledge through understanding, self-confidence and experience in the real world. Sanders states that the real application of knowledge can benefit students in learning mathematics and science Constructivism also emphasizes that learning is contextual, ie it will not happen unless the student can relate an idea or fact to a larger system.

It can therefore be seen that the constructivism theory is very relevant and meets the characteristics of the ongoing study, namely the Chem-A module based on the STEM approach. The Chem-A module encourages students to be active and ask them to build their knowledge based on the concept of chemical bonds they have learned. Additionally, activities in this module require students to perform hands-on activities. Not only that, this module also emphasizes problem-based learning and problematic issues.

This is in line with the statement by Dewey that mathematics and science learning can be enhanced by involving students with realistic and hands-on learning opportunities as well as question-based questions. It is also supported by which states that hands-on science is required to enable students to better understand the content of knowledge and process skills. Therefore, based on this theory, researchers are confident that the performance of students in STEM learning can be improved. Figure 1 shows the theoretical framework for this study.

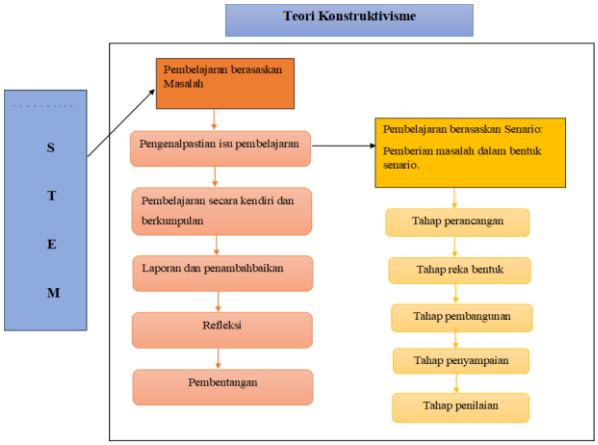

Figure1: Theorotical Framework

IV. RESEARCH' OBJECTIVES

The study aims to:

i. Developing Chem-A module based on the STEM approach in the Chemical Bond topic.
ii. Identify the effectiveness of the Chem-A modules in the Chemical Bond topic.

• Identifying students' understanding of the topic of the Chemical Bond topic.
• Identifying teachers' perspectives on the Chem-A module.

V. METHODOLOGY

Descriptive study using this quantitative approach involves 30 science stream students in one of the secondary school in Johor Bahru. The study was carried out based on a pre-experimental study design based on a group (O1 X O2) where the study was initiated with the pre-test implementation, followed by the Chem-A Module exposures and ended with the post test implementation. Sample selection was determined based on the purposive sampling method where this purposed sample was selected for the group who had in-depth information on the topic to be studied. Pilot study was conducted to obtain the pre-post test confidence index. Alpha Cornbach value is 0.78. For quantitative methods, researcher use a survey study that quantitative data is collected based on the test questions given to the students in looking at the effectiveness of the module in terms of understanding. Both sets of tests are the same questions that comprise of 10 objective questions and four subjective questions covering the entire topic of the Chemical Bond. Overall, the items in this test are adapted from the Malaysian Examination Certificate (SPM) questions from 2010 to 2016. The data obtained from the tests are reviewed manually and then analyzed descriptively in the SPSS package (Statistical Package For Social Science Version 22.0) to obtain the frequency values, percentage and mean. The t-test (paired sample t-test) is used to compare the mean difference of student achievement test score in pre test and post test. Next, it also aimed to see whether there is a significant difference between these two tests. Frequency and percentage techniques are used in analyzing each item in the objective part and subjective section items.

Furthermore, besides students'understanding, some teachers' views were also sought to identify their perceptions of this Chem-A module. In order to answer the third question, 10 teachers were given a questionnaire with the Chem-A module. This questionnaire involves closed questions and open questions. This method is still in quantitative design. The selection of this method is because the data through the open question serves as support data to the quantitative approach. The set of questionnaire forms is divided into three sections, namely Part A, Part B and Part C. Part A contains two items namely gender and teaching experience. Part B is questions related to the Chem-A Module. In total, this section contains 28 items. There are three constructs which is the contents of the Chem-A Module containing 10 items, the teaching strategy on Chem-A Module contains 11 items and STEM's teaching and learning features consist of 7 items. While, section C is an open-ended question which is a general assessment that requests teachers to give the suggestions for improvement and overall opinions or suggestions. Answers are written in the blank space provided. Frequency and percentage values are also used in analyzing questionnaires. Whereas, coding methods will be used in open-ended questions.

VI. RESULTS

The Chem-A module is specific to the Chemical Bondtopic for Form four chemistry subject. This module is based on the ADDIE model, using the STEM approach through problem-based learning and the problem is given in the form of scenarios.

The ADDIE model consists of five phases according to the sequence of analysis, design, development, implementation and evaluation. In the analysis phase, the researchers carry out two levels of analysis, namely, the analysis of the content and analysis of the user, the student. The results of the analysis found that respondents were from good level of achievement and respondents consisted of more girls than boys.

In addition, for content analysis, the researcher identified that students already learn the Chemical Bond topic. The purpose and objectives of the learning are also identified as to apply the STEM approach in Chemical Bond topic and to address the problems of students in this topic. The problem toward this topic was identified based on past studies in which the studies find that students are confused whether the compound is an ionic bond or covalent bond, the student can not draw the exact compound formation and so on. Furthermore, the results of the analysis found that no further teaching techniques using STEM approach in this topic was applied. Based on the analysis, the design phase is carried out for module development. This phase comprises front page design, introduction, rationale, module objectives, teaching procedures and teaching & learning sessions. After both phases of analysis and design are found to be appropriate, the Chem-A Module was developed. Hence,

the development of Chem-A module is initiated with first

sections such as the introduction, rationale, goals and objectives of the module and the concept of Chemical Bond. In addition, this module is continued with the teaching and learning section in which this module use the STEM approach and the formation of lesson plans for learning that applied problem-based learning approaches. The problem is in the form of scenarios. Additionally, daily lesson plans and answer suggestions were also included in this module. The prepared teaching modules have been presented to students in the form and arrangement that have been developed. The purpose is to see the effectivenessusing this new approach which is STEM approach. The results showed that the implementation of the Chem-A Module took about 1 hour and 30 minutes and the study found that the students in the group were able to solve the problem. Exposure module ends with evaluation phase. This phase is to evaluate the effectiveness of the module in meaningful learning in order to overcome the problems in learning especially in the topic of the Chemical Bond. Pre and post-test were given to students and questionnaires for teachers. Figure 2 shows the module's front cover, the STEM component applied in the module and among the problems used.

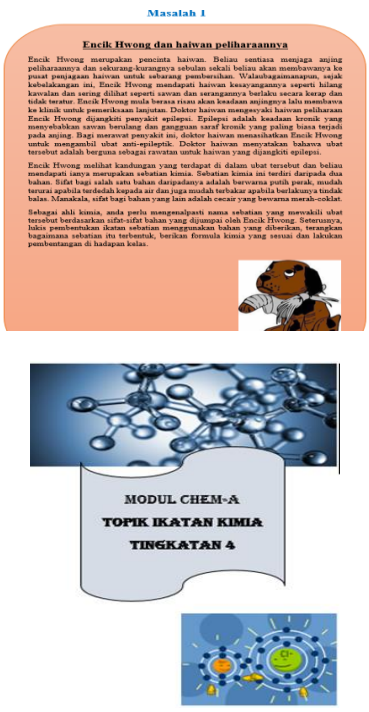

Figure2: Module's front cover, the STEM component applied in the module and the problems

The students' understanding was identified based on the achievement of students' overall marks in pre-test and post-test. Student achievement was analyzed by comparing pre-test and post-test scores. Based on Table 1 which shows the achievement of 30 students in pre and post-test, lowest score and highest score in pre-test are 16% and 74%. Meanwhile, for the post-test, the lowest and highest marks are 50% and 95%. Additionally, the significant difference of marks was 66%, which is from respondents R14.

Table 1: The Achievement of Students' Overall Marks in Pre-Test and Post-Test

Respondent	Pre-test (%)	Post-test (%)	Difference (%)
R1	53	61	8
R2	66	79	13
R3	60	76	16
R4	74	87	13
R5	61	97	36
R6	16	71	55
R7	45	71	26
R8	58	89	31
R9	30	79	49
R10	34	61	27
R11	29	50	21
R12	32	55	23
R13	47	89	42
R14	26	92	66
R15	18	63	45
R16	26	61	35
R17	55	58	3
R18	66	55	-11
R19	47	53	6
R20	55	92	37
R21	55	84	29
R22	58	95	37
R23	66	84	18
R24	53	82	29
R25	74	84	10
R26	63	89	26
R27	76	84	8
R28	37	89	52
R29	58	84	26
R30	48	82	34

The t-test (paired t-test sample) was conducted to test whether there was a significant difference between the students' pre-test score and the students' post-test score.

Table 2 shows an increase in mean scores from 49.53 to 76.53 which is 27.00. The mean increase clearly shows that the use of the Chem-A Module can help increase the level of understanding of students in mastering the topic of the Chemical Bond. Furthermore, the result of the t-test analysis as in Table 3 shows that there is a significant difference between the mean score of the pre test and the mean score of the post test at the confidence level .05. It can be seen that its significant value is .000 and it does not exceed .05. Hence, there is a significant difference between the mean score of the pre-test and the mean score of the post-test.

Table 2: Paired Sample statistics of Pre-Test and Post Test

Test	N	Mean	Std. error mean	Std. deviation
Pre-test	30	49.53	3.076	16.850
Post-test	30	76.53	2.586	14.163

Table 3: T-test of Pre & Post-Test

Paired Differences					t	df	Sig. (2-tailed)
Mean	Std. deviation	Std. Error Mean	95 % Confidence Interval of the Difference				
			Lower	Upper			
-27.000	17.122	3.126	-33.394	-20.606	-8.637	29	.000

It can be concluded that the student achievement score in the post test (M = 76.53, SD = 2.586) is higher than the student achievement score in pre test (M = 49.53, SD = 3.076). There is a significant difference, T (30) = - 8.637, P, 0.05, d = 0.720.

Hence, this study received H_1 which is there were differences between pre and post-test. By that, it can be stated that the difference in the level of achievement of the Chemistry topic through post test shows the effects of the Chem-A Module exposure that integrates STEM approach.

To look at the effectiveness of the Module Chem-A more profoundly, data analysis for each item is performed. Table 4 shows the six questions for the ion bond construct in the objective part. This section is to answer the second research' objective, namely the effectiveness of the module in terms of student understanding. The student's decision to answer the question correctly and the student's decision to answer the question wrongly is shown in frequency (f) and also percentage technique (%).

Table4: Data analysis for Ionic Bond in Objectives Part

Item	Pre-test		Post-test	
	Frequency of students answer the questions correctly (f) and percent correct (%)	Frequency of students answer the questions wrongly (f) and percent wrong (%)	Frequency of students answer the questions correctly (f) and percent correct (%)	Frequency of students answer the questions wrongly (f) and percent wrong (%)
1	26 (86.7%)	4 (13.3%)	28 (93.3%)	2 (6.7%)
2	27 (90.0%)	3 (10.0%)	29 (96.7%)	1 (3.3%)
3	26 (86.7%)	4 (13.3%)	29 (96.7%)	1 (3.3%)
5	7 (23.3%)	23 (76.7%)	22 (73.3%)	8 (26.7%)
6	20 (66.7)	10 (33.3%)	25 (83.3%)	5 (16.7%)
10	26 (86.7%)	4 (13.3%)	27 (90.0%)	3 (10.0%)

Furthermore, data analysis is continued with the covalent bond construct. Table 5 shows four questions for the covalent bond construct in the objective part. This section is to answer the second research' objective, namely the effectiveness of the module in terms of student understanding. The student's decision to answer the question correctly and the student's decision to answer the question wrongly is shown in frequency (f) and also percentage technique (%).

Table 5: Data analysis for Covalent Bond in Objective Part

Item	Pre-test		Post-test	
	Frequency of students answer the questions correctly (f) and percent correct (%)	Frequency of students answer the questions wrongly (f) and percent wrong (%)	Frequency of students answer the questions correctly (f) and percent correct (%)	Frequency of students answer the questions wrongly (f) and percent wrong (%)
4	25 (83.3%)	6 (16.7%)	27 (90.0%)	3 (10.0%)
7	24 (80.0%)	6 (20.0%)	28 (93.3%)	2 (6.7%)
8	17 (56.7%)	13 (43.3%)	28 (93.3%)	2 (6.7%)
9	15 (50.0%)	15 (50.0%)	22 (73.3%)	8 (27.3%)

Table 6: Data analysis for item in subjective part

Overall, based on the results of the student scoring analysis for each item of objective section, the frequency of students responding correctly to the post-test increases compared to the students answer the questions correctly in the pre-test. Hence, this demonstrates that the development of Chem-A Module enhances students' understanding in the Chemical Bond topic. It is attributed to the approach of the teaching strategy that is based on STEM based on problem-based learning and the problem is given in the form of scenarios.

Data analysis is continued with items in the subjective section. The subjective part consists of four questions that cover all the subtopics in the Chemical Bond topic. Table 6 shows four questions in the subjective section. This section is to answer the second research' objective, namely the effectiveness of the module in terms of student understanding. The student's decision to answer the question correctly and the student's decision to answer the question wrongly is shown in frequency (f) and also percentage technique (%).

Based on the analysis of the answers in pre & post-test, it can be seen that there is an increase in the frequency of the students responding to questions correctly for question 1 up to question 3 (a) in the post test compared to the pre test.

For question 3 (b), score is given based on student response level. This question carries 3 marks. Table 7 shows the frequency of students getting 0 marks, 1 mark, 2 marks and 3 marks in pre and post test.

Item	Pre-test		Post-test	
	Frequency of students answer the questions correctly (f) and percent correct (%)	Frequency of students answer the questions wrongly (f) and percent wrong (%)	Frequency of students answer the questions correctly (f) and percent correct (%)	Frequency of students answer the questions wrongly (f) and percent wrong (%)
1(a)	22 (73.3%)	8 (26.7%)	28 (93.3%)	2 (6.7%)
1(b)	15 (50.0%)	15 (50.0%)	24 (80.0%)	6 (20.0%)
1(c)	11 (36.7%)	19 (63.3%)	28 (93.3%)	2 (6.7%)
1(d)	9 (30.0%)	21 (70.0%)	23 (76.7%)	7 (23.3%)
2(i-Y)	27 (90.0%)	3 (10.0%)	29 (96.7%)	1 (3.3%)
2(i-Z)	7 (23.3%)	23 (76.7%)	22 (73.3%)	8 (26.7%)
2(ii)	21 (70.0%)	9 (30.0%)	30 (100.0%)	0
2(iii)	11 (36.7%)	19 (63.3%)	19 (63.3%)	11 (36.7%)
3(a)	23 (76.7%)	7 (23.3%)	30 (100.0%)	0

Table 7: Data analysis for Queston 3(b)

Item	Pre-test	Post-test
	Frequency of students answering the questions according to the marks (f) and percentage (%)	Frequency of students answering the questions according to the marks (f) and percentage (%)
3(b)	0 marks: 8 (26.6%) 1 marks: 5 (16.7%) 2 marks: 17 (56.7%) 3 marks: 0	0 marks: 0 1 marks: 2 (6.7%) 2 marks: 19 (63.3%) 3 marks: 9 (30.0%)

Next, for question 4, marks are given based on the student's answer level. Question 4 carries 10 marks. Table 8 shows the frequency of students getting 0 marks, 1 mark up to a full score of 10 in pre and post-test.

Table 8: Data Analysis for Question 4

Item	Pre-test		Post-test	
	Frequency of students answering the questions according to the marks (f) and percentage (%)		Frequency of students answering the questions according to the marks (f) and percentage (%)	
4	0 marks: 13 (43.3%) 1 marks: 1 (3.3%) 2 marks: 0 3 marks: 1 (3.3%) 4 marks: 6 (20.0%) 5 marks: 3 (10.0%)	6 marks: 0 7 marks: 2 (6.7%) 8 marks: 4 (13.3%) 9 marks: 0 10 marks: 0	0 marks: 7 (23.3%) 1 marks: 0 2 marks: 1 (3.3%) 3 marks: 1 (3.3%) 4 marks: 1 (3.3%) 5 marks: 2 (6.7%)	6 marks: 2 (6.7%) 7 marks: 3 (10.0%) 8 marks: 3 (10.0%) 9 marks: 6 (20.0%) 10 marks: 4 (13.3%)

Based on the answers to the questions in question 3 (b) and question 4, the frequency of students getting high marks in post-test increases compared to the marks in pre-test. Hence, this demonstrates that the development Chem-A Module enhances students' understanding in the Chemical Bond topic. It is attributed to the approach of the teaching strategy that applied STEM through problem-based learning and the problem is given in the form of scenarios. Overall, all items showed an increase in post-test scores compared to pre-test.

The efficacy of the Chem-A Modules used to aid the learning process of students is further strengthened with the perspectives of teachers. The questionnaire consists of four constructs namely the content, teaching strategies, teaching and learning features of STEM and open question. The first construct in this questionnaire was on the contents of the Chem-A Module as in Table 9. In the questionnaire, VNT represent very not agree, NT represent not agree, A represent agree and VA represent very agree.

Table 9: Frequency and Percentage Value of Chem-A Module Content Constructs

Item		Frequency and Percentage (%)			
		VNA	NA	A	VA
1	The teaching content of the Chem-A Module suitable to the syllabus of learning.	0 (0)	1 (10)	4 (40)	5 (50)
2	No error in the content of Chem-A Module.	0 (0)	0 (0)	7 (70)	3 (30)
3	The teaching materials of the Chem-A Module are easy to understand.	0 (0)	1 (10)	3 (30)	6 (60)
4	Teaching in Chem-A Modules relevant to daily applications	0 (0)	0 (0)	6 (60)	4 (40)
5	Chem-A Module information is linked to students' prior knowledge	0 (0)	0 (0)	6 (60)	4 (40)
6	The contents of the Chem-A Module are arranged in order	0 (0)	0 (0)	5 (50)	5 (50)
7	Delivery materials in the Chem-A Module are easy to understand	0 (0)	0 (0)	4 (40)	6 (60)
8	No spelling errors in the Chem-A Module	0 (0)	0 (0)	5 (50)	5 (50)
9	Difficulty levels such as terms, approaches and contents of the Chem-A Module correspond to target groups	0 (0)	0 (0)	6 (60)	4 (40)
10	Teaching appropriate for various target groups	0 (0)	0 (0)	6 (60)	4 (40)

The second construct in the questionnaire was about the teaching strategy of the Chem-A Module. Table 10 shows the frequency value and the percentage of items in the teaching strategy construct.In the questionnaire, VNT represent very not agree, NT represent not agree, A represent agree and VA represent very agree.

Table 10: Frequency and Percentage of Teaching Strategies in the Chem-A Module

Item		Frequency and percentage(%)			
		VNT	NA	A	VA
1	The teaching objectives of the Chem-A Module are clearly written.	0 (0)	0 (0)	4 (40)	6 (60)
2	The teaching objectives of the Chem-A module can be achieved.	0 (0)	0 (0)	7 (70)	3 (30)
3	The Chem-A Module teaching strategy is in line with the students' level of thinking.	0 (0)	0 (0)	7 (70)	3 (30)
4	Chem-A Module teaching method is very effective for use.	0 (0)	0 (0)	6 (60)	4 (40)
5	Chem-A Module teaching methods challenge students' minds.	0 (0)	1 (10)	5 (50)	4 (40)
6	Students get to involve themselves in teaching and learning.	0 (0)	0 (0)	7 (70)	3 (30)
7	Students will be happy during the teaching and learning activities of the Chem-A Module.	0 (0)	0 (0)	3 (30)	7 (70)
8	The Chem-A Module teaching strategy is in line with the time allocated.	0 (0)	1 (10)	6 (60)	3 (30)
9	The Chem-A module helps students understand more easily.	0 (0)	0 (0)	5 (50)	5 (50)
10	The teaching methods in the Chem-A Module used are easy to apply.	0 (0)	0 (0)	5 (50)	5 (50)
11	Chem-A Module teaching strategy is very interesting	0 (0)	0 (0)	4 (40)	6 (60)

The third construct in the questionnaire was about STEM's teaching and learning features in the Chem-A Module. Table 11 shows the mean score, frequency and percentage for this construct.In the questionnaire, VNT represent very not agree, NT represent not agree, A represent agree and VA represent very agree.

Table 11: Mean score, Frequency and Percentage of STEM Teaching and Learning Features

Item		Frequency and Percentage (%)			
		VNA	NA	A	VA
1	Implementation of the Chem-A Module can enhance students' sensitivity to an issue.	0 (0)	0 (0)	6 (60)	4 (40)
2	Implementation of the Chem-A Module can involve students in productive team work.	0 (0)	0 (0)	5 (50)	5 (50)
3	The implementation of Chem-A Modules can involve students in open inquiries and exploration.	0 (0)	0 (0)	5 (50)	5 (50)
4	Implementing the Chem-A Module requires students to provide various answers / solutions with justification.	0 (0)	0 (0)	6 (60)	4 (40)
5	Implementing the Chem-A Module requires students to apply STEM content understanding.	0 (0)	0 (0)	4 (40)	6 (6)
6	Implementation of the Chem-A Module gives students the opportunity to improve their answers or products.	0 (0)	0 (0)	3 (30)	7 (70)
7	Implementation of Chem-A Modules involves students applying designing process skills.	0 (0)	0 (0)	3 (70)	7 (70)

In conclusion, from the questionnaire analysis on STEM's teaching and learning features in the Chem-A Module, the overall data showed that the respondents agreed with almost the entire item presented.

For general assessment, there are five open items comprising aspects, suggestions and overall views of the respondents on Chem-A Module of the Chemical Bond topic. Among the aspects favored by the respondents are the issues that are given are clear, informative, this module can attract students, students can perform their own activities as well as fun activities and good module layout and it is easier and clearer for teachers to understand. On the other hand, the respondents only provide feedback in terms of module content ie the use of many sentences and less use of diagrams. The suggestions given to improving this module are in terms of teaching strategies where they say that researchers need to diversify their learning aids, asking students to make their own problems based on current issues, adding more issues in KBAT and materials and ways of building models can be opened to students so they can trigger creative ideas. In addition, for content in the module, respondents suggested that researchers should reduce the use of sentences and build a more comprehensive of daily lesson plan. The overall opinion given by respondents is a good teaching strategy and the module content that is interesting, good and clear. Overall, based on respondents' feedback in the questionnaire given, Module Chem-A received positive feedback. This indirectly shows that the teacher provides a good perspective on this developed module.

VII. DISCUSSION

Based on objective and subjective item analysis, it can be concluded that students can not answer all the questions correctly. This is further reinforced with the findings from previous studies that students are experiencing problems in the Chemical Bond topic. Nimmermack (2016) states that only 20% of the students were fully masteredon the Chemical Bond topic . Based on past studies conducted by Muhammad Hafidzuddin Misbah (2011), most students are confused about the difference between ionic bonds and covalent bonds. It can be demonstrated in the pre-test that have been implemented. The confusion in ionic bonds and covalent bonds were also supported by earlier studies carried out by Butts and Smith (1987).

Therefore, it can be concluded that the problems of students in the Chemical Bond topicwaerealso accepted by previous studies. Thus, the teacher should play a role to overcome this problem such as changing the teaching strategy that is more focused on the students. It is also supported by Heitzmann (2007) which states that the selection of appropriate teaching and learning methods can lead to the achievement of learning objectives and at the same time have a significant impact on the achievement and performance of the students.

This study has developed the STEM Approach based on the STEM Approach which uses this STEM approach through problem-based learning (PBL). Next, the problem is given in the form of scenarios. As a result of the implementation of this module, there was an increase in scores in the post-test. In addition, the findings show that the frequency of students responding correctly to the post-test increases compared to the students answer the questions correctly in pre-test. In addition, based on the t-test, the studies found that there was a significant score difference between pre and post-test. Hence, it can be concluded that this module demonstrates the effectiveness of the students' understanding in the the Chemical Bond topic. This is because the teaching strategies used involve students in the learning process.

Increasing in students' understanding is supported by previous studies. Among them, the findings of Chonkaew et al. (2016) show that there is a significant positive attitude towards students in science learning after STEM exposure through PBL. This can be seen when students can formulate all the knowledge they have learned on their own rather than listening to the teacher's teaching alone. Additionally, the increasing of students' understanding in the Chemistry topicwas also agreed upon by Becker and Park (2011) stating that the STEM integration approach which is usually implemented in problem solving activities shows a positive impact on students' learning especially in increasing interest and students learning. It is also supported by Kuenzi (2008) which states that STEM integration can make learning more meaningful and meaningful to the students.

Problem solving in this module encourages students to explore something, integrate the theory and apply knowledge and skills to find the solutions to overcome the problem (Savery, 2006). In addition, the findings by Senocak et al., (2007) conducting a study on science teaching using PBL indicate that there is a significant difference between the mean score of students' scores in pre-test and post-test. The findings of the Chem-A Module show that the effectiveness of the module among the students is also supported by previous studies, Tarhan et al., (2008); Afolabi and Akinbobola (2009); Senocak et al., (2007) and Yuzhi (2003) stating that teaching using PBL shows high academic achievement and significant compared to conventional teaching.

In addition, researchers believe that increasing of students' understanding is also due to the use of scenarios as an activity problem. It is supported by Trona and Trna (2014) which expresses student's interest to be enhanced by providing scenarios as a problem. This is because the scenario will raise many questions among students.

Hence, it is clear that STEM approach has many benefits to the students. The development of Chem-A module involves students in all STEM components in which they study science, technology, and engineering knowledge in terms of building electron structures of compounds visually and mathematically. The result of this module reveals

significant differences in student post test compared to pre test. Therefore, it can be concluded that students' understanding increases after the Chem-A Module exposures.

Furthermore, researcher have reviewed the elements found in the Chemistry-A Module based on STEM Approach in the Chemical Bond topichelp improve students' understanding. Overall, the findings show that the use of elements in terms of content, teaching strategies and the teaching features of the STEM approach in this module is at a good level. This means that teachers agree that this module is able to increase the level of understanding of the students in the Chemical Bond topic. Additionally, this module can also improve students' interest in learning the topic of Chemistry, which will be easier for students to understand and faster for work to solve problems. It is supported by Trona and Trna (2014) which expresses student's interest to be enhanced by providing scenarios as a problem.

VIII. SUMMARY

The findings show that students' understanding of the topic of Chemistry is enhanced through the implementation of the Chem-A Module based on the STEM approach and this module receives positive feedback from teachers. From the findings, it can be seen that a teacher who diversifies teaching strategies can help students improve their understanding of a topic. This is due to the interesting learning activities that can enhance student interest and encourage active learning to better understand the concept of chemical bonds. Active learning can also be seen when they are eager to work in groups. It is also agreed by Nurshamshida et al., (2013) which states that the way teachers deliver teaching and learning are among the factors that need to be emphasized in reducing the problem of learning concepts. Hence, it is hoped that this module will provide an overview of the teachers to apply STEM elements in their teaching process. Not only that, this module gives teachers the idea of using other teaching strategies that can make learning materials more interesting.

REFERENCES

1. Azizah Mohamad dan Shaharom Noordin (1999). Tahap Penguasaan Kemahiran Saintifik Pelajar Tingkatan Empat Daerah Kulai. *Buletin Persatuan Pendidikan Sains dan Matematik Johor*. 9: 28-36.
2. Butts, B. dan Smith, R. (1987). Chemistry Students' Understanding of the Structure and Properties of Molecular and Ionic Compounds. *Research in Science Education*.17: 192-201.
3. Crawley, F. E. dan Black, C. B. (1992), Causal modeling of secondary science students' intentions to enroll in physics. *Journal of Research Science*. 29(6), 585–599.
4. Chonkaew, P.,Sukhummek, B. dan Faikhamta, C. (2016). Development of analytical thinking ability and attitudes towards science learning of grade-11students through science technology engineering and mathematics (STEM education) in the study of stoichiometry. *Chemistry Education Research and Practice*.17: 842-861.
5. Dewey, J. (1963). Experience and Education. The Kappa Delta Pi Lecture series: New
6. York, NY: Macmillan Publishing Company.
7. Glynn, S. dan Duit, R. (1995). Learning Science in the Schools. Mahwah, NJ: Lawrence Erlbaum Associates.
8. Harrison A. G. dan Treagust D. F., (1996), Secondary students' mental models of atoms and molecules: implications for teaching chemistry. *Science Education*. 80: 509–534.
9. Heitzmann, R. (2007). Target Homework To Maximize Learning. *Education Digest*.
10. 72(7): 40-43.
11. Ilhan, N., Yildirim, A. dan Yilmaz, S.S. (2016). The Effect of Context-based Chemical Equilibrium on Grade 11 Students' Learning, Motivation and Constructivist Learning Environment. *International Journal Of Environmental dan Science Education*. 11(9): 3117-7137.
12. Jones, M.G. dan Brader-Araje, L. (2002). The Impact of Constructivism on Education: Language, Discourse, and Meaning. *American Communication Journal*. 5(3): 1-10.
13. Jesse, S.N., V.Twoli, N. dan Maundu, J.N. (2014). Enhancement of Science Performance through Computer-Assisted Instruction among Selected Secondary School Learners in Kenya. *Kentucky Journal of Excellence in College Teaching and Learning*. 12(4): 51.
14. Johnson, D.W., Johnson, R.T. dan Smith, K.A. (2013). Cooperative Learning: Improving University Instruction By Basing Practice On Validated Theory. *Journal on Excellence in University Teaching*. 1-26.
15. Kennedy, T. J. dan Odell, M. R. L. (2014), Engaging students in stem education. *Science Education International*. 25(3). 246–258.
16. Kuenzi, J. J. (2008). Science, technology, engineering, and mathematics (STEM) education: background, federal policy and legislative action. *Congressional research service*. 4-35.
17. Kementerian Pendidikan Malaysia (2013). Pelan Pembangunan Tindakan Malaysia (2013-2025).
18. Kementerian Pendidikan Malaysia. (2016). Panduan Perlaksanaan Sains, Teknologi, Kejuruteraan dan Matematik dalam Pengajaran dan Pembelajaran.
19. Kyere, J. (2017). Effectiveness of H ands-on P edagog y in STEM Education. Walden University. 1-209.
20. Muhammad Hafidzuddin Misbah. (2011). Kerangka Alternatif Pelajar dalam Topik Ikatan Kimia. *Universiti Teknologi Malaysia*.
21. Nimmermark, A., Ohrstrom, L., Martensson, J. dan Davidowitz, B. (2016). Teaching of chemical bonding: a study of Swedish and South African students' conceptions of bonding. *Chemistry Education Research and Practice*. 17: 985-1005.
22. Nurshamshida Md Shamsudin, Nabilah Abdullah dan Nurlatifah Yaamat. (2013). Strategies of Teaching Science Using an Inquiry Based Science Education (IBSE) by Novice Chemistry Teachers. *6th International Conference on University Learning and Teaching*. 583-592.
23. Ozmen, H. (2004). Some Student Misconceptions in Chemistry: A Literature Review of Chemical Bonding. *Journal of Science Education and Technology*. 13(2): 147-159.
24. Osborne, J. dan Dillon, J. (2008). Science education in Europe:critical reflections (A Report to the Nuffield Foundation). London: King's College.
25. Peterson, R. F. dan Treagust, D. F. (1989). Grade-12 students'misconceptions of covalent bonding and structure. *Journal of Chemical Education*.66(6): 459-460.
26. Piaget, J. (1970). *Genetic epistemology*. The Norton Library. 1-84.
27. Savery, J. R. (2006). Overview of Problem-based Learning: Definitions and Distinctions. *Interdisciplinary Journal of Problem-Based Learning*. 1(1): 9–20.
28. Senocak, E., Taskesenligil, Y. dan Mustafa Sozbilir. (2007). A Study on Teaching Gases to Prospective Primary Science Teachers Through Problem-Based Learning. *Research in Science Education*. 37: 279-290.
29. Sanders, M. (2009). STEM, STEM education, STEMmania. *The Technology Teacher*. 68(4): 20–26.
30. Taber, K. S. (1993). Student conceptions of chemical bonding: using interviews to follow the development of A level students' thinking. *Facets of Education Dimensions of Research*.1-18.
31. Tarhan, L., Ayar-Kayali, H., Urek, R.O. dan Acar, B. (2008). Problem-Based Learning in 9th Grade Chemistry Class: 'Intermolecular Forces'. *Research in Science Education*. 38: 285-300.
32. Tami Levy Nahum, Avi Hofstein, Rachel Mamlok-Naaman dan Ziva Bar-Dov. (2004). Can Final Examinations amplify Students' Misconceptions in Chemistry? *Chemistry Education: Research and Practice*. 5(3): 301-325.
33. Trnova, E. dan Trna, J. (2014). Motivational Effectiveness of a Scenario in IBSE. *Social and Behavioral Sciences*. 167: 184-189.
34. Yuzhi, W. (2003). Using Problem-Based Learning in Teaching Analytical Chemistry. *The China Papers*. 28-33.