CONSTRUCTION OF *MODUL CELIK MOL* TO INCREASE THE EFFECTIVENESS OF THE PROCESSES OF TEACHING AND LEARNING SCIENCE

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Abstract

Effective teaching module is needed in the teaching and learning of science process to enhance students' construction of concepts. This study develops a teaching module, 'Modul Celik Mol' to help overcome an alternative framework problem and enhance math skills for the topic of mole concept among students. This module is built based on analogy methods of teaching. In addition, various additional elements such as consolidation and evaluation activities were applied. To assess the appropriateness and effectiveness of this module, twelve chemistry teachers in the district of Johor Bahru were chosen as respondents. Data were collected using a set of questionnaire and analyzed by using descriptive statistics involving frequency and percentage. The findings showed that all respondents gave positive opinions on the suitability of the module to be applied in the process of science teaching in schools and it also can enrich the references material for students in chemistry subject. This study certainly opens a new chapter in the world of effective teaching of science education.

Introduction

Chemistry is one of the most important subjects taught in schools in Malaysia. In this country, achievement reports of Sijil Pelajaran Malaysia (SPM) in 2003-2004 stated that the topics of 'chemical formulas and equations', 'atomic structure', 'periodic table', and 'chemical bond' are among the basic chemistry subjects needed to be stressed (Kementerian Pendidikan Malaysia, 2004). However, most students have problems in those chemistry topics, which contain the foundations of mathematics such as the topic of 'chemical formulas and equations' (Aziz & Hasnah, 1990; Gilbert & Watts, 1983; Md Nor & Nur Afza, 2010). This topic requires students to have a strong mathematical foundation to enable them to understand the mathematical concepts are used in chemistry subjects. The mole concept is one of the main concepts taught in "chemical formulas and equations." It is important because it is the main thrust used in the next chemistry topic such as rate of reaction, oxidation and reduction and thermo chemistry. Students often have a problem with the mole concept because they do not understand it clearly. If students cannot understand the concept, then they will not understand the next topics connected with the concept. This issue is then associated with building an alternative framework in the construction of this concept in students' minds.

Students Difficulties in Mastering the Mol Concept

Many researchers have stated that chemistry is a subject which contains many difficult to understand and abstract concepts (Gabel, 1999; Yalcinalp, Geban, & Ozhan, 1995). The mole

concept is one and it also is of the most important subtopics in chemistry. The word 'mole' is a uniquely chemistry concept (Uce, 2008). The word comes from Latin that is 'moles', which means heap or pile. In chemistry, the word mole gives meaning of a pile or heap of atoms, molecules, ions, and so on. The learning and teaching processes in chemistry for the mole concept is a major challenge to teachers and students because the it involves many mathematical calculations, new chemistry terms and abstract facts that are difficult to master by the students, especially students who are weak in math skills (Gabel & Sherwood, 1984; Niaz, 1996; Reid & Yang, 2002). The difficulties in mastering the mole concept can be divided into two alternative frameworks the mole concept and the mathematical skills associated with the mole concept.

Alternative Framework for Mole Concept

Studies have shown that there is a variety of alternative framework in mastering the mole concept. Among them are (1) difficulty in mastering moles terms that are various and misleading. The basis of misleading the mole is in the definition of 'standard units for the amount of a substance'. Cervellati, Montuschi, Perugini, Grimellini-Tomasini, and Pecorini Balandi (1982) examined 13 chemistry textbooks used by schools in Italy. Most of the text gave no precise definition and some textbooks even gave a false definition. (2) Failure to build a relationship of moles to mass, volume and number of particles. The study found that students became confused when the concept of moles was associated with volume and mass of different materials. There was a variety of disagreements when it was alleged that the mole is the quantity of material containing a certain number of particles or a unit of the part while others believed that the mole was a unit of calculation. Uce (2008) in his study stated that students could not link molar mass and relative atomic mass, and the relationship between molar mass and relative atomic mass to the mole and atom mass unit.

Math Skills Problem for Mole Concept

The second problem faced students learning the mole concept was related to mathematical skills. Mathematical knowledge is knowledge of the calculations in the mole concept. Students who do not master this knowledge have difficulty solving the mole concept problem. The problems related to mathematical skills can be divided into three kinds. First is the algorithm. In the mole concept, the algorithm needs to be applied rigorously to solve the problem according to the rules or procedures, step by step until one gets the answer. According to Frazer and Servant (1987) students faced difficulties since they were unable to bring the problem to its solution because of a lacking in knowledge of the algorithm. Thus, algorithm knowledge can assist and guide students in solving problems with the mole concept in accordance with the step by step procedure until the end (Abdul Rahman, 2005). The second reason is mathematics. BouJaoude and Barakat (2000) found that low mathematical reasoning among students made it difficult to understand the mole. They felt that these difficulties could be reduced by distinguishing between the quantity with the number and replace moles in stoichiometric calculations with a particle number as a unit of computation. The third reason is standard form of numbers. According to Esguerra and Punzalan (1983), difficulties with the moles concept were due to the standard form of numbers. The value of 6.02×10^{23} is too large and it is also a difficult figure for students to do mathematical calculation if the rules needed for these operations weak in the students. Mathematical operations such as multiplication and division involving these numbers add to the difficulty because it involves the decimal point and exponent.

Clearly the variety of problems mastering the mole concept is very important and is basic to many more complex chemistry concepts. Consequently, effective teaching strategies are needed to help students overcome their problem in the concept construction process.

An Effective Teaching Strategy for Understanding of the Mole Concept

Teaching strategies based on efforts to help students overcome problems in constructing the mole concept should be implemented. Therefore, this research chose an effective teaching strategy, which was the analogy method in devising the 'Modul Celik Mol'. This method provided an opportunity for students to develop the mole concept by themselves through understanding and knowledge. The analogy method is a teaching technique using 'parable' to represent a concept to be taught (Allan & Richard, 2008). This method helps students to improve their knowledge in scientific concepts. This method is important in describing an object or process, especially on something which cannot be seen such as atoms and molecules. This method gets attention because it is able to explain easily the ideas of abstract learning. The three principles for the use of analogy are focus, action and reflection (Allan & Richard, 2008). Through this strategy, students can be guided to overcome their difficulties in mastering the mole concept. Therefore, this study seeks to build 'Modul Celik Mol' based on the topic of the mole concept using these three teaching strategies in an effort to help students to master the concept effectively. Based on the teachers' opinion, this study also evaluates the effectiveness of the module in the teaching process.

Construction of 'Modul Celik Mol' Based on Effective Teaching Strategies

'Modul Celik Mol' was developed as a guide to teachers in overcoming the existing problems in teaching the mole concept (Figure 1).

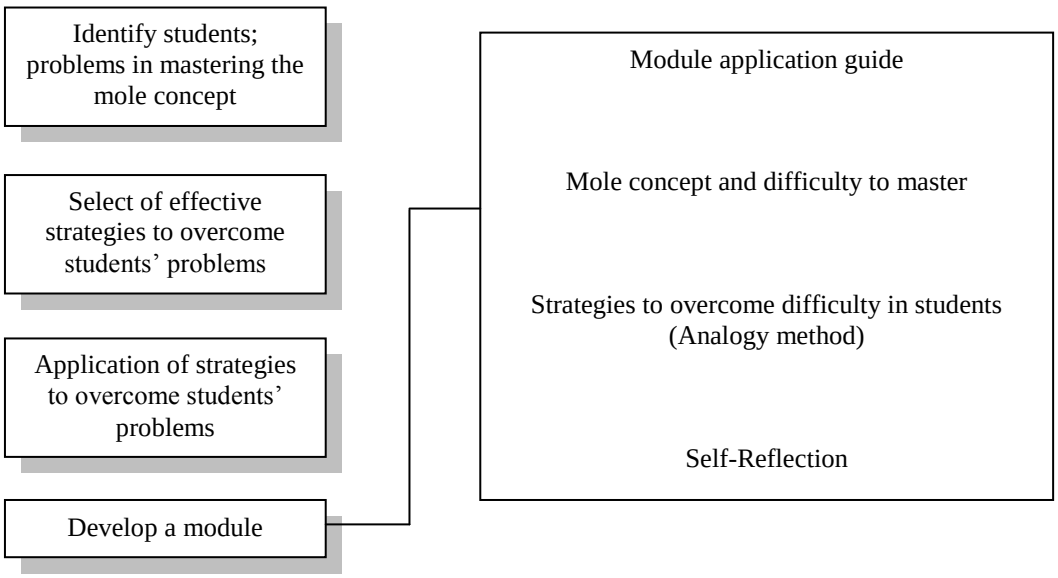

Figure 1. Design for the Construction of 'Modul Celik Mol'.

This module was developed through four stages, namely (1) identify students' problems in mastering the mole concept, (2) select effective strategies to overcome students' problems, (3) apply strategies to overcome students' problems, and (4) build 'Modul Celik Mol'. It was also built based on the syllabus issued by the Curriculum Development Centre (2005). The design contains four main components: module application guide, mole concept and the difficulty to master it, strategies (analogy) to overcome the difficulties and self reflection. It is

presented in the form of text and graphics to facilitate the use of this module. Here is an example of the module content (Figure 2) of the analogy strategy. It gives the analogy of an area consisting of five islands and it is used to show the analogy to the topic of the mole concept.

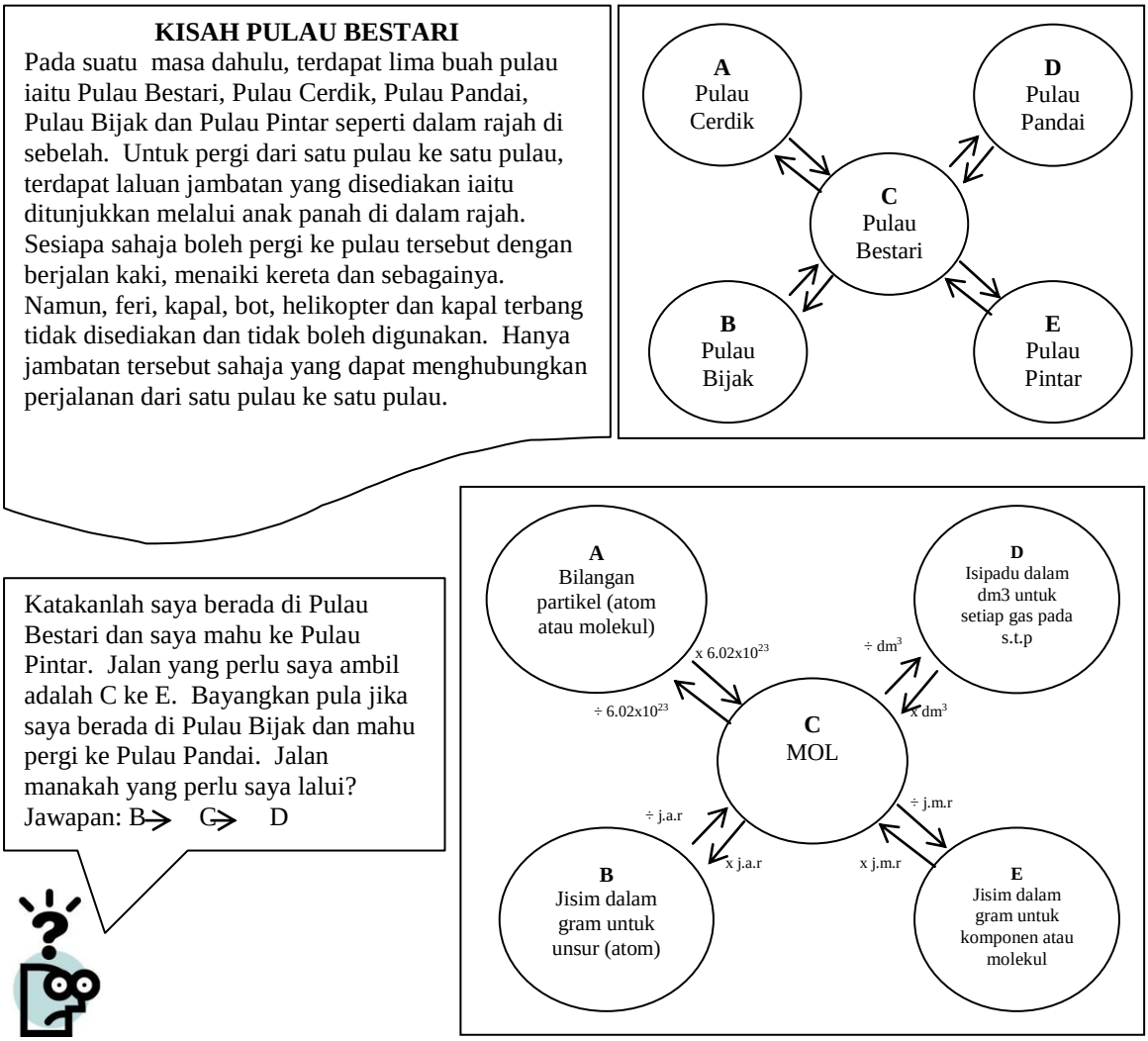

Figure 2. An example of the analogy.

Through this module the teacher can explain the similarities between the pictures of the story of Bestari Island with the mole concept. Students can be guided to understand the relationship between moles, mass, volume and number of atoms with how that can be used to convert the units of each concept. It becomes very important to realize the relationship between each concept would explain possible conversion unit. It also explains the concept of the mole as a single entity such as dozen is a standard measurement unit (Gabel & Sherwood, 1984). Recognizing the difficulties students faced in order to understand this relationship, analogy serves to develop students' understanding by giving easier, concrete and meaningful examples (Allan & Richard, 2008). For example, if students want to know the number of particle in 12g of carbon, they have to convert it to mole unit first (12g is equivalent to one mole). Then, students need to convert it to the number of particle by multiplying it with Avogadro constant ($6.02x10^{23}$ particle). In order to assist students' understanding, they can form an analogy by associating the task with someone's journey from Pintar Island to Cerdik Island and they have to go through Bestari Island first. The teaching stages using the Analogy

method can be summarized as in Appendix A. Overall this module provides guidance to teachers to teach the moles concept overcome students' learning difficulties.

Suitability of Modul Celik Mol in the Teaching Process

To assess the suitability of the built modules, a set of evaluation forms was developed and validated by two experts. To improve reliability, a pilot study was conducted on three chemistry teachers. Feedback received indicates that the instrument used is easy to understand, consistent with the level of respondents and able to measure the objectives of the study. Then, the instrument was distributed to twelve chemistry teachers in the district of Johor Bahru. The respondents were randomly selected. Data were analyzed using descriptive statistics involving frequency and percentage. Results of the study are discussed based on the three categories content, teaching strategies and general assessment.

Content

Result of the analysis as in Table 1 shows that the respondents were satisfied with a few of the items in the assessment module. This is shown by the 100 % percentage in those items as shown in Table 1. The figure proves that the module achieved its objectives in some aspects especially its suitability with the syllabus, relation with students' prior knowledge and organization of contents. It is also easy to understand and appropriate to the target group. In general, the respondents agreed that the contents of the modules were organized. This allows a more structured, orderly and efficient learning.

Table 1
Suitability of Module Content

Item	Agree		Disagree	
	N	%	N	%
1. The teaching content is suitable with the syllabus	12	100	0	0
2. No error in content	8	66.7	4	33.3
3. Teaching material is easy to understand	8	66.7	4	33.3
4. Teaching is relevant with daily application	8	66.7	4	33.3
5. Information is related with students' prior knowledge	12	100	0	0
6. Content is organized	12	100	0	0
7. Delivery language is easy to understand	12	100	0	0
8. No error in spelling	4	33.3	8	66.7
9. Difficulty levels of the term, approach and content are appropriate to the target group	12	100	0	0
10. Teaching is available and suitable to be used by the target group	12	100	0	0
Average Percentage Distribution		83.3		16.7

This finding is supported by Rashidi and Abdul Razak (1995) who stated that the delivery of orderly and smooth learning content would facilitate the process of teaching to be done in three stages, beginning of lesson, development and closing. With an average of 83.3 % the respondents indicated that the content of the modules was very good. This result means that majority of the respondents were with the content of the module. However, there is a weakness such as a few spelling errors in the instruction and examples. Some of the respondents (33.3 percent) mentioned that the content materials are difficult to understand and irrelevant to their daily application. This feedback may be referred to the examples on

Bestari Island which are less meaningful and not related to the students' daily lives. According to Mohd Ali, Ahmad Nurulazam, and Zurida Ismail (2003) contextual examples of the contextual nature can facilitate interpretation and assist in the process of relating a concept with experience and existing knowledge.

Teaching strategies

Results of the analysis show that the respondents were very satisfied with a few of the assessment items of the module. This notion was shown by the 90.36 per cents who agreed that the module had achieved its objectives in introducing an alternative teaching strategies for teachers, these are given in Table 2. All respondents agreed that the learning objectives are clearly written. In addition, the set induction is effective and attractive. It also encourages creativity and concepts construction. They also agreed that the teaching strategies in the module allow students to participate in the teaching and learning process. Overall, the method was able to help them formulate their effective teaching strategies to help students master the mole concept.

Table 2
Teaching strategies

Item	**Agree**	
	N	**%**
1. Learning objective is clearly written	12	100
2. Learning objective can be achieved	8	66.7
3. Effective set induction	12	100
4. Organized delivery	12	100
5. Teaching method attracts attention	12	100
6. Teaching method encourages active learning	11	91.7
7. The user was encouraged to be creative	12	100
8. Module encourages concept construction	12	100
9. Subtopics were linked nicely	11	91.7
10. Students were involved in teaching and learning	12	100
11. Analogy method was suitable in teaching mol concept	11	91.7
12. Contextual method was appropriate to teach the mole concept	10	83.3
13. Problem-solving method was suitable for teaching the mole concept	12	100
14. Diversity of methods could assist in the teaching process	12	100
The average percentage distribution		90.36

This result is supported by the effectiveness of the teaching method (analogy) in science teaching. For example, using the analogy method, Black and Solomon (1987) examined how students used an analogy to understand electrical current. This notion also supports the constructivist theory of analogy allowing students to build knowledge by themselves by forcing them to see new knowledge within the analogy framework. It is also supported through the use of the contextual method. The contextual approach states that learning occurs only when students (learners) process information or relevant knowledge new to them in their reference frame (Centre for Occupational Research and Development, 1999). Learners will develop their own knowledge through the learning progress. Similarly, the use of the problem-solving method was also tested in other research. Ausubel, Novick, and Hanesian (1978) focused on problem solving as a form of composite learning and high cognitive activity helping in the process of obtaining meaningful learning. In contrast to memorized learning, meaningful learning can help students to understand concepts. Through memorized learning, students can only remember but lack of understanding of the concepts.

General assessment

Table 3 shows the general responses of teachers for the purpose of the improvement of this module. All respondents thought the analogy method used in this module is very effective and some teachers assumed that the Bestari Island story and strategy implementation (analogy) presented in this module is the most favoured aspects. However, a few respondents suggested that there should be more examples of analogous (66.7 percent) and the examples should be contextual in order to assist students in developing effective meaning (66.7 percent).

Table 3
General Assessment

ITEM	RESPONSES	%
1. The most preferred aspects	Teaching method	33.3
	How to implement	33.3
	Bestari Island story	33.3
2. The aspect mostly in need of improvement	Less of contextual examples	66.7
	Need more analogy example	33.3
3. Suggestion to improve	Present more contextual examples	66.7
	Present more analogy examples	33.3
4. The effective method to teach the mole concept	Analogy method	100
5. Will you suggest this module to other people?	Yes	100
6. Suggestion and overall comment	Creative Module	66.7

With the percentage of 100%, all respondents strongly agreed that the analogy method was an effective method to teach the mole concept. As stated earlier, the analogy method is a teaching technique that uses a 'parable' which is used to represent a concept to be taught. The story of Bestari Island was used to attract the interest of students to understand the mole concept, and gain meaningful knowledge in the mole concept. The effectiveness of the use of the analogy method in the mole concept is proven through previous research. Furio, Azcona, and Guisasola (2002) stated that the problems and difficulties to understand the concept of mole can be overcome by the use of the right analogy. In the present study, all of the respondents also agreed to suggest the module other teachers, because the method helps facilitate the process of teaching and learning. Furthermore, respondents also said that the module is very interesting and creative.

This study shows that the method used in the module is attractive and affordable to help students understand the lessons. In contrast to conventional learning, where students rely on teachers and memorization systems, students can easily bore and do not acquire proper knowledge. This is supported by Tengku Sarina and Yusmini (2006) when she mentioned that the effective teaching methods could increase students' motivation in learning by stimulating interest and enthusiasm. Students will not be bored if they are interested in the learning process.

Conclusion

One of the efforts to obtain effective teaching is through the use of a module based on analogy teaching methods. It can also organize and systematize the teaching and learning

processes. In addition, students can be motivated to be interested in learning and thinking critically.

Acknowledgement
This work was supported by the Ministry of Higher Education and Universiti Teknologi Malaysia (Research University Grant, Vote number: Q.J130000.7131.04J00).

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APPENDIX A: Example of lesson

Subject : Chemistry **Form** : 4 Arif
Time : 1 hour **Topic** : Numbers of mole
Objective : At the end of this lesson, students will be able to develop ideas about mole.
Prior knowledge : Students already know the definition of mole.

Teaching and Learning Activities:

Phase	Activities	Learning Focus
Focus Phase	Teacher tells Bestari Island story to the students with Diagram and makes an analogy with mole concept. Teacher gives an example to the students to make a relationship between Bestari Island and Mole concept using Bestari Island story: *If I am at Pulau Bestari and I want to go to Pintar Island, which pathway that I need to choose?* Answer: C→E Then, teacher gives another example: *If I am at Cerdik Island and I want to go to Pintar Island, which pathway that I need to choose?* Answer: B→C→D Teacher explains the relationship between Bestari Island story with mole concept using a diagram.	Students make a relationship between journeys in Bestari Island story with change a unit in mole concept.
Action Phase	Teacher gives a question about the concept of mole to the students and instructs students to answer. Question: *Find the mass of 3 moles of oxygen atoms* Students are required to use the figure earlier taught as a reference. Teacher checks students' answers and the process of discussion. Teacher gives students tips on how to answer the questions given.	Students can evaluate their understanding of the mole concept and story analogy Bestari Island
Reflection Phase	Teacher assesses students understanding by providing a new and more difficult question. Question: *Find the number of molecules in 6 dm ^{3} of nitrogen gas.* Teacher will see if students are able to answer the question and discussions with students will be conducted. Teacher identifies strengths and weaknesses of the method of analogy in the process of teaching and learning.	Students strengthen their understanding of the concept of moles in the title.