“Typical” teaching method applied in chemistry experiment

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Abstract

This article reports the findings of experiment teaching strategy which is typically practiced by the student teachers. In this study, student teachers are required to perform experiments and presented through teaching and learning styles in the classroom. The qualitative study was conducted among purposely selected 10 student teachers. Data were collected through video of the teaching and learning process and interviews. The findings showed the student teachers tend to perform the direct instruction or highly structured instruction which also known as the traditional approach of experiment in their teaching and learning presentation. The traditional approach mentioned here often referring as “recipe learning” which often engage the students to learn passively or during the whole experiment without engaging any thinking but follow the procedures given by teacher. Thus, the study had suggested the respondents to change or improve their teaching method while teaching experiment by implementing the inquiry strategy and constructivism approach.

1. Introduction

Chemistry is a subject that involves experimentation which could be more exciting whenever conducted through laboratory experiment where the results are more memorable by their senses (Ledwith, 2000). It is also a study of the composition, properties and behaviour of matter (Helmenstine, 2012). Sirhan (2007) stated that chemistry is one of the vital branches of science since most of the topics basically about the structure of matter which provides explanation and enables the students to understand the occurring phenomena. Lunette et al. (2007) explained that experiment is a learning experience in which students communicate with materials or with secondary sources of information to observe and understand the natural world (Dillon, 2008). There are many purposes of doing experiment in chemistry. Some of the most frequently stated reasons are to encourage precise observation and explanation, to make situation more real, to stimulate and maintain attentiveness, to promote a logical and reasoning technique of understood (Dillon, 2008). Dillon (2008) also listed other purposes of experiments usually stated by teacher after the introduction of the National Curriculum in England and Wales. There are to improve student’s problem understanding skill and find the solution, to develop a critical thinking and to develop a skill to cooperate each other to find a facts and achieving new information. According to the Integrated Curriculum for Secondary School for Chemistry Form 4 (2005), experiment requires the students to get involve in hypothesis testing by going

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through a sequence of investigations to find out or discover specific science concepts and underlying applied principles.

Although the curriculum urges the teachers to let the students to conduct experiment, but there is a research that shows teachers strongly advocate the use of practical, it has to be noted that there is, as many places in school education, a gap between policy and practice, between written in the policy and the actual action that teacher practices, and what do student teacher experience themselves (Dillon, 2008). Lunette et al. (2007) highlight that even with current change of emphasis towards learning outcome, results show that there is a ‘chasm’ between the outcome that teacher identify before the class and the actual outcome that their students perceived (Hodson, 1993, 2001; Wilkinson and Ward, 1997). According to Tamir and Lunetta (1981), even with the transformation of curriculum to improve the quality of experiment, students still waste too much time in experiment by reading and following the ‘recipes’ or procedures. It results in students’ failure to perceive the conceptual and procedural understandings that teachers want to achieve for the experiment (Lunetta et al., 2007).

2. Background of the problem

Hofstein and Mamlok-Naaman (2007) highlighted that experience gained through laboratory work is known over the past century as being able to enhance and pursue the central science education goals which include improving and enhancing the comprehension of students toward the concepts in science and the application of it; scientific practical skills and problem solving abilities; scientific mind and personalities; realize the works in science and how it carried out by scientists; interest and motivation. However, is such case is true? The answer to that is probably no. Hodson (1991) had claimed that the practical work “as practiced in many countries, is ill-conceived, confused and unproductive. For the students, learning in the laboratory can only contribute little knowledge to their learning of science. Based on the statement given by Hodson (1991), it seems that there is still a long way to go in order to achieve the central science education goals.

Dillon (2008) had stressed out that there exist a gap between the learning outcomes that is set by the teachers before carrying out experiments and the actual outcomes that students received at the end of experiment since students fail to comprehend the conceptual and procedural understandings of the laboratory activities. In the research of Liu and Lin (2007) on improving chemistry experiment teaching methods, they had highlighted that one of the main problems existing in teaching experiment was the traditional approach where students obtained results through the emphasize of training session in competence of procedure, observation and memory capacity had limited the opportunity for students to think, imagine analyse and innovate. Similarly, Dillon (2008) stated that most of the students prefer to tag along the “recipes” passively during the experiment thus it only enable students to practice skills at low level. Johnstone et al. (1994) pointed out that many teachers had developed the awareness that most of the behaviour performed by the students while conducting experiment is just like following the ‘recipe’ where they were able to gain scientific skills but through following a set of procedures in the manual without cognitive engagement. This type of experiment teaching will not be helpful in promoting understanding of the nature of science, especially chemistry. Johnstone (1991) emphasized that learning chemistry involves the transition of threefold representations and they are macroscopic, sub-microscopic and symbolic level. Students had encountered difficulties to carry out transition in these three level of representations yet during the teaching of laboratory often required the students to develop observation at the level of macroscopic only but later that the teachers expecting the students will be able to interpret the results of the experiment in microscopic level (Johnstone, 1991).

It is undeniable that applying experiment as a teaching method to teach chemistry is useful and it is able to improve both concept and students’ skills but the way of carrying out the experiment and the degree of students engagement during the experiment is the main concern to determine the effectiveness of what had students obtained while conducting experiment. Thus this study attempt to i) determine teaching methods applied by student teachers in carrying out experiment; ii) Identify weaknesses in the teaching method as applied by the student teachers in experiment and iii)Identify the perspectives of respondents toward the teaching method they had applied.
3. Methodology

This study was a case study that had been carried out among ten chemistry student teachers who had undergone practical teaching during the previous semester II 2011/2012. They are student teachers from the course Bachelor of Science and Computer with Education (Chemistry) at the Faculty of Education of Universiti Teknologi Malaysia. In this study, qualitative data had been collected through video recording of the process of teaching through experimentation as demonstrated by the respondents (student teachers) on three different days which were 9th, 16th and the 23rd of October 2012. During their presentation on teaching on doing the experiments, the ten chemistry student teachers had been divided into five groups where there were two persons in a group. This study was carried out to critically review the teaching methods being employed by the five groups of chemistry student teachers while teaching experiment. The experiments as presented by the five groups mainly focused on the topics in Form 5 Chemistry. Besides the video recording, the lesson plans that they had prepared for the day was also collected as one of the resources for the study. A short interview with the respondents was carried out to determine their point of views on supporting the teaching method that they had applied in teaching experiment. All of the qualitative data were reviewed by the researchers. Results were reported and tabulated. The teaching method applied by the student teachers will be compared with the best strategies suggested by the previous researches. The characteristics of the three teaching strategies were identified and they were direct instruction, inquiry strategy and constructivism approach. The characteristics of the three teaching strategies were summarised as follow:

| Characteristics | Direct Instruction Santrock (2009) | Inquiry Strategy Savery (2006) | Constructivism Approach Poh (2003) |
|-----------------|----------------------------------|--------------------------------|-----------------------------------|
| • Directed and controlled by teacher | • Provide hands-on learning opportunities | Needham Five Phase Model Consist five phases: | |
| • High expectation on students progress | • Appropriate materials given to students to manipulate or operate | a. Orientation | To attract students attention and interest |
| • Concentrate on academic tasks and activities | • Teacher provides an encouraging problem and appropriate amount of help and assistance | b. Eliciting ideas | To be aware of student’s prior knowledge |
| • Minimise the negative affects | • Students centered | c. Restructuring of ideas | To realize the presence of other ideas, ideas need to be improved, to be developed or to be replaced with scientific ideas. |
| • Less application on non-academic materials (games, and toys) | • Students are given freedom to manipulate their ideas in their own understanding | Four important features in this stage: | |
| • Less non-academic interactions between students and teacher | • Active learning approach which focused on questioning, critical thinking and problem solving | i. Explanation and exchanging ideas | |
| | • Stages involved in inquiry learning often begin with question followed by investigating solutions, creating new knowledge as information is gathered and understood, discussing discoveries and experiences and reflecting the new-found knowledge | - To identify the alternative ideas and critically assess the present ideas | |
| | | ii. Exposure to conflict ideas | - To test the validity of the present ideas |
| | | iii. Development of new ideas | - To improvise, develop or to replace with new ideas |
| | | iv. Evaluation | - To test the validity of the new ideas |
| | | d. Application of ideas | To apply the new ideas to a different situation |
| | | e. Reflection | To adapt ones idea to the scientific ideas |
4.0 Result

The followings are the results obtained from the study.

4.1 Teaching methods applied by future teachers in experiment

Table 2, 3, 4, 5 and 6 shows the typical teaching methods applied by the student teachers while demonstrating experiment to the students;

| Teaching Methods Applied while Teaching Experiment | Indicators |
|---------------------------------------------------|------------|
| • Highly structured and teacher centered teaching method (traditional approach) incorporate with maximum level of inquiry. |
| • Included the early two stages of Needham Five Phase Model which are orientation and eliciting idea. |
| • In short, direct instruction dominated the teaching method applied been applied by the group. |

| Table 2: Student teachers’ teaching methods while teaching experiment and the indicators |
| Group 1: Chemicals for Consumer (Soap Preparation Process) |

| Teaching Methods Applied while Teaching Experiment | Indicators |
|---------------------------------------------------|------------|
| • Carried out questioning session trying to engage students in learning and also elicit the understanding of student. As an example, the respondents asked the students what will happen if the sodium hydroxide solution used in the experiment being replaced by potassium hydroxide solution. |
| • Attracting the attention of students by showing video on soap commercial. |
| • Discussed the content of experiment before students start their experiment. |
| • Set high expectation toward student’s progress where students required accomplishing two learning outcomes in an experiment that conducted in a period of lesson, 40 minutes. |
| • Students were provided with a set of well-prepared procedures to follow. |
| • Emphasized on academic materials like practical book, when the respondents discussed the questions in the practical book. |
| • Throughout the experiment, teacher controlled the activities of the students. |
| • Minimum participation of students in practical work since only two students requested to demonstrate the experiment. |
| • During the demonstration, teacher acts as the instructor where giving instructions to students what to do for each steps. |

| Table 3: Student teachers’ teaching methods while teaching experiment and the indicators |
| Group 2: Rusting as a Redox Reaction (The Effect of Other Metal on Rusting) |

| Teaching Methods Applied while Teaching Experiment | Indicators |
|---------------------------------------------------|------------|
| • Teacher centered teaching with minimum amount of hand on activities but massive amount of questions given to students. |
| • Engaging the three early stages of Needham Five Phase Model which are orientation, elicitation and restructuring idea. |
| • In short, the respondents applied direct instruction. |

| • Respondents had attracted the attention of students by applying the rusting occurs on spoon and asked question about how rust affect the health to relate rusting of experiment. However, the set induction is slightly irrelevant to the topic of the experiment. |
| • Minimum hands-on activities since there are no experiment carried out in actual and it had been replaced with video on respondents demonstrating the experiment. |
| • Respondents conducted lecture and discussion rather than actual experiment. |
| • Respondents lectured on the hypothesis, variables, materials, apparatus and procedures to carry out the experiment. |
| • In lecture and discussion, the respondents provide questioning session and handouts to students to guide the students to elicit and restructured the ideas of students. |
| • Respondents controlled and directed throughout the discussion on the results of the experiment. |
Table 4: Student teachers’ teaching methods while teaching experiment and the indicators

| Group 3: Thermochemistry |
|--------------------------|
| **Teaching Methods Applied while Teaching Experiment** | **Indicators** |
| • Highly structured and teacher centered teaching method | • Large amount of interactions between respondents and the students in the discussion on the pictures related to the concepts of exothermic and endothermic. |
| • In short, direct instruction had been applied by respondents | • Well written handouts and procedures had prepared and provided to students to guide students throughout the experiments which carried out in groups. |
| | • Before the experiments, the respondents had explained the procedures and the materials involved to students. The students had been reminded by respondents to follow the procedures that had explained in graphic representations. |
| | • Respondents requested the students to finish the experiment as fast as possible. |
| | • Respondents shown the effort in attracting students during the lesson by having innovative demonstrations on extreme change in temperature. However, demonstrations done by respondents and no participation from students. Lack of hands-on activities for students. |
| | • During the demonstrations, respondents did not prompt question to students to enable them to think critically and creatively. |
| | • Lack of questioning or enquiry during the experiment. |

Table 5: Student teachers’ teaching methods while teaching experiment and the indicators

| Group 4: Alcohol (Chemical Properties of Ethanol) |
|-----------------------------------------------|
| **Teaching Methods Applied while Teaching Experiment** | **Indicators** |
| • Highly structured and teacher centered teaching method. | • The topic of experiment was introduced at the beginning of the class. |
| • In short, direct instruction had been applied by respondents. | • Attracting students attention by using different intonation and voice but no activities done before the experiment as medium to introduce the lesson. |
| | • Explained the aims, problem statement, hypothesis, variables and apparatus of the experiment before begin to conduct the experiment. |
| | • Respondent had miss out the step of explaining the safety precaution for the experiment and aware when the students in a way to conduct the experiment. |
| | • Students are provided with the explanation of procedure before the experiment by showing it using power point. |
| | • Students are guided to conduct the experiment to get the actual results of the experiment. |
| | • Minimum participation of students in discussion of the result and observation. |
| | • Respondents controlled the whole experiment and discussion of the experiment. |

Table 6: Student teachers’ teaching methods while teaching experiment and the indicators

| Group 5: Alcohol (Oxidation of Fe2+ to Fe3+ and reduction of Fe3+ to Fe2+) |
|-----------------------------------------------|
| **Teaching Methods Applied while Teaching Experiment** | **Indicators** |
| • Moderate level of structured and teacher centered teaching method. | • Respondents attracted the attention of students by a demonstration of color changing related with the topic. |
| • Included two stages of Needham Five Phase which are orientation and elicitation of ideas. | • There is no question and answer while students presented their results and observation. |
| • Included inquiry learning when conducted presentation of data by students. | • The discussion of the results and observation of the experiment are conducted after the presentation of observation and result by students. |
| | • Respondents show a video of observation of data collected using different oxidizing and reducing agents with different identification reagents. |
| | • Students are explained about the safety precaution needed and are asked to read the procedure before conducting the experiment. |
Based on the data collected on the teaching methods applied by the student teachers while teaching experiment, researcher identified that all group members applied direct instruction method based on the characteristic of direct instructions that can be seen as the indicator of the methods being used. All of them seems to apply teaching experiment based on teacher-centered rather than students-centered and they used structured method of conducting experiment. Even though they know that there are other effective methods as compared to traditional methods in teaching experiment, they had their own reasons of sticking to that method that will be discussed later in this section. Three of the groups of respondents emerged mostly only two or three early stage of Needham Five Phase Constructivism Model in their teaching that are orientation, elicitation of ideas and restructuring of ideas. Only one of the group members appeared to use low minimum level of inquiry in teaching experiments. It shows that the student teachers had made the effort in improving their teaching method yet they were still categorized as educators who teach in a traditional way. Similar to this is the research by Shymansky et al. (1997) who explained a common science classroom and teacher where:

“The classroom was a self-contained lecture-laboratory room. The teacher, a middle-aged man with a strong academic background in physical science, was an active graduate student pursuing a masters degree in science education at a local university. He expressed commitment to many constructivist ideas. He was enthusiastic about implementing ideas that he had researched at the university, and valued hands-on/minds-on activities, collaborative problem solving, and communities of learning. However, to some extent he was restricted in his teaching values and intentions by the need to complete the requisite subject matter of the unit of study within an allotted period of time. Nevertheless, within the traditional structure of the science department in his school, his lessons included strategies and activities that promoted knowledge construction and discourse opportunities. He used whole-class discussion for organization of the day’s activities, and students frequently worked in small groups to complete experiments, reports, and study guides” (p. 576).

4.2 Weaknesses in the teaching methods applied by student teachers in experiment

Table 7 presents the weaknesses found in the teaching methods applied by the student teachers;

| Weaknesses in Teaching Methods Applied while Teaching Experiments | Frequency |
|---------------------------------------------------------------|-----------|
| Discussed the content of experiment before students start the experiment. | 4         |
| Set high expectation toward student’s progress in experiment | 2         |
| Students were provided with a set of well-prepared procedures to follow | 3         |
| Emphasized on academic materials like practical book | 1         |
| Teacher controlled the activities of the students in term of experiment, discussion and demonstration | 4         |
| Minimum participation of students in practical work | 2         |
| Minimum hands-on activities | 1         |
| Conducted lecture and discussion rather than actual experiment. | 1         |
| Lack of questioning or enquiry during the experiment, demonstration and discussion of the observation and result data. | 2         |
| Requested the students to finish the experiment as fast as possible | 1         |

In this research, the researchers had gathered the weaknesses of the methods applied by the student teachers while teaching experiment. Based on the tabulated data, most of the respondents discussed the content of experiment such as aim, material, apparatus, variables and elements those had to be identified during experiment before students were allowed to conduct the experiment. This is understandable as to why the student teachers did so with the hope that explaining everything before the experiment would help the students to know what they were doing and looking for during the experiment. The same reason was found in the study from Abraham and Millar (2008) about the “recipe style” tasks that was practiced during laboratory work and they explained that the behaviour of the teacher...
who emphasized on students understanding about the procedures in the experiment which they need to follow later and in the mindset of the teacher. Success in experiment means that the students were able to develop the expected or desired phenomena that the teacher had set for and made the correct observations for the particular experiment. Furthermore, another frequent weakness being identified when the experiment teaching method was applied was, the experiments were mostly conducted under the student teachers’ control in terms of activity in experiment, discussions and demonstrations. The probable reason for this is that the teacher hoped that experiment being conducted was under their controllable range and to ensure that the reality stick with what they had planned. This seems to be true since when the researchers asked the respondents about why they used the teaching method in teaching experiment, most of them stated that it was much easier and three of the respondents even stated out that the method they applied enable them to control the class. Nevertheless, the least weaknesses that is visible in this study were minimum hands-on activities, respondents tend to conduct the experiment using lecture and discussion rather than doing the actual experiment and they also asked students to finish the experiment as quickly as possible. Some of the student teachers were also likely to emphasize on academic materials like practical book by doing discussion on questions in the practical book. Another weaknesses as shown in this study are lack of questioning or enquiry during conducting the experiment, demonstration and discussion activities on the data of results and observations, less participation of students in practical work because only some of the chosen students were asked to demonstrate the experiment. Moreover, some of the student teachers were unable to set limitation of the goals that they wanted the students to achieve and they set too high expectation towards students’ progress in during experimentation. They also provided set of well-prepared procedures to follow and the experiment activity did not allow freedom for the students to conduct their own experiment.

4.3 Perspectives of respondents toward the teaching method they applied

Table 8 illustrates student teachers’ perspective towards the teaching method that they had applied.

| Perspective of Respondents Toward The Teaching Methods They Applied | Frequency |
|-----------------------------------------------------------------|-----------|
| Time saving                                                     | 6         |
| Able to enhance students understanding toward the procedures in experiment | 1         |
| Easy to carry out                                              | 4         |
| Common teaching method that had been use to it                  | 3         |
| Enable teacher to control and manage the class                 | 3         |
| Allow the learning outcomes that set earlier being accomplished | 3         |

All the respondents in this research had their own perspectives for choosing and applying the teaching methods in teaching experiments. All of the six respondents said that due to time constraint, they prefer to use direct instruction method. The least perspectives appeared to be the reason of respondents towards the teaching methods that they had applied is that to be able to enhance students understanding towards the procedures in experiments. There were other perspectives as stated by them about the teaching methods that they chose. It was because it was easy to carry out the experiment using traditional methods and it was a common teaching method. It also enables teacher to control and manage the class and allow the achievement of the learning outcomes that they had set earlier. Even though there were many barriers that prevent the conduct of more effective experiment teaching it does not signifies that the student teachers had the right to continuously apply the teaching method that they preferred yet knowing it is not effective. Thus the fourth objective of the study which is to suggest the method to improve or overcome the weaknesses, the researchers had found out two effective teaching method those are suitable for implementation instead of using direct instruction, the respondents should try implementing inquiry strategy and constructivism approach.
5. Conclusion

The researchers in this study strongly believe that experimentation can maximize the learning of the abstract concepts and theories of science, particularly chemistry given that it enables the students to engage in real practical work rather than sitting in the classroom and absorbing the lecture on the concepts and theories. Subsequently, Hofstein (2004) highlighted that the authentic and practical learning environment provided in the laboratory work or experiment is a totally different scenario than the actual classroom learning environment and therefore it helps to motivate students to develop interest in learning science, especially chemistry because through the experimental work, the students are able to develop the scientific skills. This point was also pointed out by Reid and Shah (2007) where they described that experimental work is the basic component of any science courses and especially on the course of chemistry. Moreover, Hofstein (2004) explained that the cognitive skills, metacognitive skills, practical skills and behaviour and interest against chemistry, learning chemistry and practical works of the students can be enhanced if the proper laboratory activities were chosen.

On the other hand, it was found that the main inhibitor for students learning concepts and skills during the experiment is not from the experiment itself but from how the teachers themselves carried out the experiment or which teaching method they used to teach experiment. Even though the ten respondents in our case study had tried to implement experiment in their teaching but the teaching method that they applied had been doubted in terms of effectiveness in assisting students in learning chemistry since all of them were highly depending on the direct instruction or highly structured instruction which also known as the traditional approach of experiment. The ten respondents had selected the traditional teaching as their choice of teaching experiment based on the six reasons and they were save more time, enhance students understanding to ward the procedures in experiment, easy to carry out, common teaching method that had been used to it, able to control and manage the class and allow the learning outcomes that set earlier being accomplished. The study had identified ten weaknesses in the tradition experiment teaching method and they were: i) discussed the content of experiment before students start the experiment; ii) set high expectation toward student’s progress in experiment; iii) provided a set of well-prepared procedures for students to follow; iv) emphasized on academic materials like practical book, when the respondents discussed the questions in the practical book; v) controlled the activities of the students in term of experiment, discussion and demonstration; vi) minimum participation of students in practical work; vii) minimum hands-on activities since there are no experiment carried out in actual and it had been replaced with video on respondents demonstrating the experiment; viii) conducted lecture and discussion rather than actual experiment; ix) lack of questioning or enquiry during the experiment, demonstration and discussion of the observation and result data and x) requested the students to finish the experiment as fast as possible. Among the ten weaknesses, the most common teaching method applied by the student teachers were they often explained the content of the experiment before carrying out the experiment and control the activities of the students in terms of experiment, discussion and demonstration. Both were the typical characteristics found in the direct instruction even some of the student teachers had implemented the constructivism approach but not entirely and found that there was only a group of respondents that incorporate minimum level of inquiry in teaching experiment.

The traditional approach mentioned here is often referred as “receipe reading” which often engages the students to learn passively or during the whole experiment without engaging any thinking but follow the procedures given by teacher. If such scenario continues, the learning of science (chemistry) will be less motivated and at the end the students will develop the attitude of only wanting to achieve the correct answer to questions in examination. Letton (1987) explained the result of the study of Sch lensenger in the year of 1935 on the role of laboratory work toward general education by saying that students who had earlier shown interest in chemistry while performing experiments had later developed the habit of achieving the expected result rather than getting interest on observing and knowing what happening in their test tube. Thus, the study had suggested the student teachers to change or improve their teaching method while teaching experiment by implementing the inquiry strategy and constructivism approach.

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