Identification of chemistry teaching problems of a prospective teacher: A case study on chemistry teaching

I W Redhana, I B N Sudria, I N Suardana, I W Suja and N K N Handayani
Universitas Pendidikan Ganesha, Bali, Indonesia
Email: redhana.undiksha@gmail.com

Abstract. This study was aimed at identifying chemistry teaching problems of a prospective teacher viewed from the conceptual change model on colloid topic. The study was conducted in one class of one senior high school in Buleleng regency, Bali. The study was a qualitative research of case study type. A number of students in the class were 27 people. The study was done in an academic year of 2013/2014 on the even semester. Methods of the study were observation and interview. The results of the study showed that new conceptions related to the necessity aspects were that the prospective teacher did not discuss the colloid concepts comprehensively and profoundly. On the other hand, the chemistry teaching problems related to the intelligibility aspects were that the prospective teacher (1) asked successive questions to students, (2) asked self-answered questions, (3) gave incomplete information, (4) gave unclear information, and (5) did not ask for students’ reasons. The chemistry teaching problems related to the plausibility aspects were that the prospective teacher emphasized the less importance of the context. Finally, the teaching problems related to the fruitfulness aspects were that the prospective teacher did not provide the new conceptions that guided the inquiry on the wider fields.

1. Introduction

Students are learners who have the instinct to understand natural phenomena through observation. In an attempt to understand the phenomena they try to construct a conception [1]. This conception will be used to solve problems or explain the new phenomena encountered [2].

Educational research indicates that students’ conceptions are referred to as alternative conceptions that are strongly influenced by age and culture [3]. The alternative conceptions of students have been widely reported by some researchers [4]. In general, the alternative conceptions are misconceptions [5] and these misconceptions are resistant or difficult to change using the traditional learning strategies. In the process of learning teachers should be able to change the alternative conceptions into scientific conceptions. Therefore, they should challenge students’ cognitive so that their understanding of the natural phenomena is disturbed. With these disturbances, students can change their conceptions. These changes are called as a conceptual change model [6]. In the conceptual change model, students are not satisfied with their conceptions because the conceptions cannot be used to explain the natural phenomena and/or to solve the problems encountered well. When this happens, students will experience dissatisfaction with their own conceptions. Therefore, they need new conceptions that are able to explain the natural phenomena or solve the problems encountered. Furthermore, the new conceptions must be intelligibly understood (intelligibility aspect). Likewise, the new conceptions must be able to solve problems (plausibility aspect) and the new conceptions must be extended to
other events and open up new areas of inquiry (fruitfulness aspect). A number of studies have been conducted regarding the conceptual change model [7] [8]. All science learning is supposed to be able to make conceptual changes when the students’ conceptions are unable to cope the challenges.

A colloid is one of the important topic studied in chemistry. Application of the topic in everyday life is very much, for example in food, medicine, cosmetics, and water treatment. With regard to the colloid application, students should be able to understand the concepts of colloids and their application well. By so doing, they will be able to utilize the concepts learned to help themselves and others.

Because of its complexity, chemistry must be taught comprehensively and coherently. Researchers have observed various problems related to the mastery of the chemistry concepts. Some of these problems are students’ misconceptions. Some of these misconceptions are found on the topics of chemical equilibrium, acids and bases, electrochemistry, matter and its change, chemical bonds, physical and chemical changes, and solutions [9], hydrocarbons [10], and buffer solutions [11].

SMA Negeri 1 Singaraja is a favorite school in Singaraja city and many of the junior high school graduates want to go to school here. Many achievements have been achieved by SMAN 1 Singaraja, such as Olympic champions either at local, regional, national, and even international level. However, previous research findings suggested that students had misconceptions about basic chemistry concepts. Redhana and Kirna [12] reported that students of SMAN 1 Singaraja had misconceptions about the topics of atomic structures, periodic table, and chemical bonds.

Every year SMAN 1 Singaraja provides teaching practices for prospective teachers, including the prospective teachers from Chemistry Department of Ganesha University of Education. Like teaching in general, the teaching done by the prospective teachers should be able to change the old conceptions of students so that students' understanding of the concepts learned for the better. However, in fact, there are so many problems encountered by prospective teachers when they practice teaching at schools [11]. Some of these problems are as follows. First, they have no mental readiness and feel insecure as they practice teaching in school. Second, they lack chemistry contents well before they practice teaching. Third, they do not consider the prior knowledge of students in making lesson plans so that the plans are not directed to the conceptual change strategy.

In this research, we would like to investigate the chemistry teaching problems faced by a prospective teacher who taught at SMAN 1 Singaraja. These teaching problems were then grouped according to the conceptual change model Posner et al. [6] which included aspects of necessity, intelligibility, plausibility, and fruitfulness.

2. Theoretical framework
The conceptual change model of Posner et al. [6] comes from the history and sociology of sciences of Kuhn [13] and from the developmental psychology of Piaget [13]. Kuhn's view of the scientific revolution explaining the scientific discovery will lead to a new scientific methodology [13]. Piaget, on the other hand, describes how students learn through assimilation and accommodation of knowledge [14]. Assimilation processes are an adjustment of knowledge learned by students with existing schemes. In contrast, accommodation processes are the change of the existing schemes by the knowledge learned because the schemes are unable to explain the natural phenomena and/or to solve the problems. Posner et al. [6] explain that the conceptual change model is similar to the scientific revolution of Kuhn and the accommodation of knowledge of Piaget.

In the conceptual change model, Posner et al. [6] propose four aspects of the conceptual change. The four aspects of it include (1) dissatisfaction with the old conceptions, followed by the new conceptions must be (2) intelligible, (3) plausible, and (3) fruitful. In the first aspect, that is, the dissatisfaction with the existing conception, the students must realize that their own conceptions are inconsistent with the existing conditions and these conceptions cannot be used to solve the problems faced. These inconsistencies by Kuhn [13] are called an anomaly. The second aspect is that the new conceptions that are accommodated must be intelligible. It means that they are not only reasonable but also students can explain them well. The third aspect is that the new conceptions are plausible. It means that the new conceptions being learned must be able to be used or applied to solve problems
encountered. The fourth aspect is that the new conceptions being accommodated must be fruitful. It means that they must be extended to other events and open up new areas of inquiry.

3. Method
The study was a qualitative research of case study type. The subjects of the study were students in one class from SMAN 1 Singaraja Bali. The selection of the class was done by purposive sampling. The consideration used to select the class was because the class was taught by a chemistry prospective teacher. The study was conducted in the odd semester of the academic year 2013/2014. The number of students involved in the study was 27 people. Identification of teaching problems was done by observing the chemistry teaching processes on colloid topics conducted by the prospective teacher. In addition, the chemistry teaching processes were also recorded with a video recorder. All notes on the board were copied into the field notebook. Video recording played back to make the transcription. The transcription made was also enriched by the notes found on the board made by the chemistry prospective teacher and students. The transcription was read by the researcher and then the sentences were smoothed to obtain a better meaning of the transcription. The results of the transcription were then cross-checked to the prospective teacher to obtain approvals related to the contents of the transcription. If the prospective teacher agreed with the contents of the transcription, he/she was required to give a signature. The transcription results were then analyzed to obtain the chemistry teaching problems. The chemistry teaching problems were further grouped under the aspects of the conceptual change model, including necessity, intelligibility, plausibility, and fruitfulness.

4. Result and discussion
The chemistry teaching problems were collected through observation and recording video. The chemistry teaching problems were further classified into one of four aspects of the conceptual change model of Posner et al. [6], covering necessity, intelligibility, plausibility, and fruitfulness. The results of the study related to the chemistry teaching problems were presented in Table 1.

Table 1. The chemistry teaching problems experienced by the prospective teacher

| Characteristics of the new conceptions | Description |
|----------------------------------------|-------------|
| Necessity                              | The colloid concepts discussed by the prospective teacher were not comprehensive and not profound. |
|                                        | 1. He/she classified rough suspensions, true solutions, and colloids (Tyndall effect, homogeneous/heterogeneous, and filtering) not based on experiment. The rough suspensions, true solutions, and colloids were not grouped through experiments, but only by providing information in the form of examples. The example of the rough suspensions was a mixture of water and sand, the example of the true solution was a mixture of water and salt, and the example of the colloid was a mixture of water and milk. |
|                                        | 2. He/she did not explain the concepts of colloids thoroughly. He/she discussed fewer concepts of colloid. For example, he/she described the colloid type of liquid and solid froth, Tyndall effect, Brownian motion, adsorption, electrophoresis, coagulation and dialysis, protective colloids, colloidal properties, and colloid manufacture. In the colloid manufacture, he/she informed the colloid manufacture through condensation methods such as redox reaction, hydrolysis, double decomposition, and solvent replacement, and the colloid manufacture through dispersion methods such as mechanical method, peptization, and Bredig’s arc. He/she did not explain the principles of each process of the methods. He/she briefly explained the role |
of colloids in everyday life, such as the colloid applications in the fields of
cosmetics, foods, and pharmaceuticals.

Intelligibility

The chemistry teaching problems that arose in relation to the aspects of
intelligibility were as follows.

1. He/she asked successive questions to students. One question had not been
   answered by the students, he/she then asked another question. This could be
   seen in the following examples.
   • He/she asked: "What are the differences of Tyndall effect on solutions,
colloids, and suspensions?" "How does Tyndall effect work on
solutions?" "How does Tyndall effect work on colloids?" "How does
Tyndall effect work on suspensions?"
   • He/she asked: "What are the differences between the colloid manufacture
   through condensation and through dispersion? What are the differences?
   What is condensation? What is dispersion?"

2. He/she asked a question that is answered by himself/herself.
   • He/she asked: "What are the differences among solutions, colloids, and
   suspensions?" He/asked: "Size of the particles."

3. He/she provided incomplete information.
   • He/she stated: "The solutions are much more stable than colloids and
susensions." He/she does not explain why the solution is much more
stable than colloids and suspensions.
   • He/she asked: "What are the differences between adsorption and
coaagulation?" "He/she then states that they are very different."
   • He/she stated: "Brownian motion is irregular motion or zigzag motion of
the colloid particles. "This causes the colloids to remain stable, whereas
the suspensions are unstable and more easily precipitated than colloids."
   He/she did not explain further why Brownian motion in the colloid system
can cause the colloids to become stable.

4. He/she provided unclear information.
   • He/she provided unclear information regarding the phase differences
among solutions, colloids, and suspensions. He/she explained: "The
solution has one phase, whereas colloids and suspensions have two
phases." He/she did not explain why these happen.

5. He/she did not ask the students’ reasons.
   • He/she asked: "What are the differences between adsorption and
absorption?" The students replied: "The adsorption is on the surface, and
the absorption gets inside." He/she did not ask the student's reasons.
   • He/she asked: "Manufactures of colloids can be divided into two, what are
they?" Students answered: "Condensation method and dispersion
method." He/she replied: "Yes, correct." He/she did not ask students’
opinion about how to make colloids with both methods.

Plausibility

He/she emphasized the less importance of the context.

Fruitfulness

He/she did not provide a new conception that guides the inquiry on the wider
fields through solving complicated problems.
The results of the study showed that there were the many chemistry teaching problems experienced by the prospective teacher in terms of conceptual change models. In the aspect of necessity, he/she classified rough suspensions, true solutions, and colloids not based on experiments, but only explain the classification without the empirical facts. As a result, the colloid concepts learned by students were less meaningful. This will lead to less understanding of students to the colloid concepts. If this happens they were very easy to forget the colloid concepts learnt.

The second problem related to the aspect of necessity was that the prospective teacher did not explain the colloid concepts thoroughly. In other words, the students' understanding was partial. What happens with this problem was that students only know these concepts on “the surface.” As a result, when they applied the concepts, they experienced difficulties. The results of the study also indicated that students were not able to solve simple or complex problems of the aspects of plausibility and fruitfulness, respectively.

The chemistry teaching problems related to the intelligibility aspect were the prospective teacher asked successive questions. The point was that he/she did not give the students the opportunity to think the answer to the first question and he/she then asked the next question. In terms of theory of teaching this condition was not good because The students were not given the opportunity to develop their thinking skills or reasoning. Consequently, they will be indifferent and lazy to think. Finally, they would wait for the answers of the questions from the teacher. This fact was seen in the next teaching problems that the prospective teacher answered their own questions. This conditions tended to encourage the teacher-centered teaching, that was, teachers ask, answer, and think actively, while students as passive listeners. In other words, students were positioned as the objects of teaching, not as the subjects of learning. This teaching contradicts the paradigm of learning embraced in the curriculum that was applied recently, Curriculum 2006 and Curriculum 2013. In both curriculum, students are required to learn actively, both mind on and hand on. In Curriculum 2006 the learning that should be done by the teachers/prospective teachers is the learning cycles, including exploration, elaboration, and confirmation [15]. The learning cycle forms can be problem-based learning, project-based learning, discovery learning, inquiry learning, and etc. Meanwhile, in the Curriculum 2013, the teachers or the prospective teachers should apply a scientific approach, including observing, questioning, collecting data, processing data, and communicating [16]. The models of learning with the scientific approach were the discovery learning, the inquiry learning, the problem-based learning, the project-based learning, and etc. Indeed, both the Curriculum 2006 and the Curriculum 2013 expect the same learning approach, that is the scientific approach.

The chemistry teaching problems related to the next aspect of intelligibility were the prospective teacher provided an unclear information. The lack of clarity of information provided by the prospective teacher might confuse the students with regard to the correct concepts. The students become unable to distinguish the correct concepts and the wrong concepts. These conditions could lead to misconceptions of students.

The chemistry teaching problems related to the other intelligibility are the prospective teacher did not ask students’ reasons. By not asking these there are several possibilities that could happen. Firstly, the students might guess the answer. Secondly, the students might know the answer to the questions. In the former possibility happened, they did not know the true reasoning of the given answers. On the other hand, in the latter possibility happened, the students also did not know whether their reasoning was reasonable or not. Both of these did not establish the scientific concepts learned by the students. In other words, students did not understand the concepts deeply.

The chemistry teaching problems related to the aspect of plausibility were that the prospective teacher emphasizes the less importance of the context. This can be seen from at least the discussion about the application of colloids in everyday life. Indeed, colloids have very high applications in everyday life, such in the food industries (e.g. ice cream, jelly, and jellyfish), cosmetic industries (e.g. powders, lipstick, and deodorant), and in pharmaceutical industries (e.g. ulcer drugs, cough and syrup), as well as in the natural phenomena, such as fog, smoke, froth, and foam. The aims to learn chemistry are to become a someone who literates on chemistry, that are they can explain the
phenomena that occur in everyday life and solve the problems encountered with regards to the chemistry concepts. These problems are closely related to the chemistry teaching problems related to the fruitfulness aspect, namely the prospective teacher did not confront the students with the problems that guide them to do an inquiry in the wider fields. As a result, they only memorize colloid concepts. This will cause students to easily forget the concepts learned. The further consequences are that they cannot help themselves and even others when they face problems related to colloid concepts.

The importance of identifying the chemistry teaching problems in terms of conceptual change models has been reported by de Jong, Acampo, and Verdonk [17]. By knowing the problems of teaching, it will be formulated appropriate learning strategies to overcome these chemistry teaching problems encountered. Several learning strategies have been developed to address the teaching problems related to the conceptual change model, including (a) the conceptual change texts [5] [18] [19] [20], (b) analogies [21], (c) the holistic mental model confrontation [22], (d) the web-based conceptual change texts [23], (e) the computer simulations [24], (f) the computer-based learning [25], and local culture-based 7E learning cycle model [26]. In preparing this conceptual change learning strategy, the teachers should also pay attention to the students’ learning style [27].

5. Conclusion

From the results of the study could be concluded as follows. The conditions of conceptual change model related to the aspect of necessity were as follows. The colloid concepts taught by the prospective teacher were not comprehensive and not profound. The conditions of conceptual change model for the intelligibility aspects included the prospective teacher asked successive questions to students, asked self-answered questions, gave incomplete information, gave unclear information, and did not ask for students’ reasons. The condition of the conceptual change model related to the aspect of plausibility was that the prospective teacher emphasized the less importance of the context. Finally, the condition of the conceptual change model related to the fruitfulness aspect was that the prospective teacher did not provide a new conception that guides the inquiry on the wider fields.

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