Multiple representation: The teacher’s perception in chemistry learning

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Abstract. This study aimed to explore the teacher’s perception of multiple representation in chemistry learning. The research design in this study was descriptive qualitative study. The participant in this study consisted of six chemistry teachers from several senior high schools in Indonesia. The semi-structured interviews were used for data collection. Each sample was asked about their perceptions of multiple representations in chemistry learning process. Data were analyzed by coding which were then grouped into themes. In this study, the researcher find that the teacher has actually applied chemical representations in chemistry learning, but the teacher is not yet familiar with the term of multiple representations in chemistry. Then, representations level that are often applied by teachers in learning chemistry are symbolic and macroscopic representations. Meanwhile, submicroscopic representations are still difficult to apply by teachers in chemistry learning process.

1. Introduction
Chemistry is a very important science to learn. However, chemistry is still considered a difficult subject to understand by students [1]. It is because chemistry consists of abstract concepts and topics [2]. On the basis of the abstract concepts and topic of chemistry, researchers proposed three levels of representation in chemistry, i.e. macroscopic, sub-microscopic, and symbolic levels [3][4][5]. To understand chemistry well is not only knowing about multiple representations but also being able to integrate of level macroscopic, sub-microscopic and symbolic [5]. Chemical knowledge can be represented in three main levels: (macro, sub-micro, and symbolic) has become paradigmatic in chemistry [6]. These three representations are related to each other in chemistry learning, so three representations are often called triplet relationships. The triplet relationships (macroscopic, sub-microscopic, and symbolic) play a key role as models in chemistry learning [7]. However, to understand and to integrate each of these levels of representation is a major challenge for chemistry teaching.

Chemistry learning should be implemented based on multiple representations so that chemistry learning is easy for students to understand. However, some research shows that chemistry learning is only applied at the level of macroscopic and symbolic representation [8][9]. While at the sub-microscopic representation it is still rare to apply in learning. Several studies have shown that frequent misconceptions occur at the level of sub-microscopic representation in chemistry learning [10][11][12]. However, sub-microscopic representation can significantly help to develop understanding and to correct possible misunderstandings in chemical concepts [12]. Therefore, all three levels of representation must be taught by the teacher in learning chemistry, so the chemical concepts can be easily understood by students.
Each level of multiple representations (macroscopic, sub-microscopic and symbolic) is not superior to the others, but each level complements one another in chemical concept [5]. For example; chemical phenomena at the level of macroscopic representation such as chemical reactions observed by experiments can be conceptualized into sub-microscopic representations, i.e. interactions between atoms and molecules at the particle level from reactions observed macroscopically, and translated into symbolic representations such as chemical symbols, and reaction equations [13]. Therefore, the ability to connect from one level to another is needed. [8] emphasize that multiple representation-based learning that focuses on interactions between levels is very important to apply. There are several ways that can be done to explain the concept of chemistry in multiple representations and to connect each level of representation, such as using methodologies and learning media for example, using multimedia [14][15][16][17] in learning. However, the teacher's role in learning is the main key in understanding the concept of chemistry. Besides of using multimedia or methodology to improve understanding of chemistry among all levels of representation, teacher personnel are also very important for student understanding [12]. Therefore the teachers must also know about multiple representations and be able to integrate them in chemistry learning. So, the researchers aimed to explore the teacher's perception of multiple representation in chemistry learning.

2. Method

2.1. Research design
The research design used in this study is descriptive qualitative [18]. One of the characteristics of descriptive qualitative study is the study to involve naturalistic data [19]. This study aimed to describe the teacher perceptions about multiple representations in chemistry learning. This study also aimed to categorize the multiple representations that teachers have applied in chemistry learning.

2.2. Participant
The participants in this study consisted of six chemistry teachers, with details of three chemistry teachers from Jambi (Indonesia) and three chemistry teachers from Yogyakarta (Indonesia). The purposive sampling was used to choose participants in this study. In the purposive sampling, researchers deliberately choose individuals or participants to learn or understand the main phenomena [20] being studied. In Table 1 below are data from the participants involved in this study,

| No | Name | Gender | School                               |
|----|------|--------|--------------------------------------|
| 1  | P1   | F      | SMA Negeri 4 Yogyakarta              |
| 2  | P2   | F      | SMA BOBKRI Bangun Tapan Yogyakarta   |
| 3  | P3   | F      | SMA Negeri 1 Sayegan Yogyakarta      |
| 4  | P4   | F      | SMA Negeri 2 Kota Jambi              |
| 5  | P5   | F      | SMA Negeri 4 Kota Jambi              |
| 6  | P6   | F      | SMA Negeri 10 Kota Jambi             |

2.3. Data collection
This study used interviews for data collection. A semi-structures interview is an interview conducted in this research. Interviews were conducted face-to-face interviews with participant [21]. Each participant will be asked about multiple representations in chemistry learning. Researchers also recorded interviews using the recorder application on mobile phones. Then, researchers transcribe the results of interviews that have been recorded [21].
2.4. Data analysis

Data analysis performed consisted of the preparing and organizing of data for analysis. Then reduce the data to themes through the process of coding and summarizing the code, and finally present the data in the images, tables or discussions [22]. In this study the researchers processed the data by transcribing the results of interviews with each participant to Microsoft word. The transcription process is carried out carefully line by line. Then the results of the transcript data are reduced to themes through a coding process, and represented in a discussion.

3. Result and Discussion

To answer the research objective, the researchers conducted semi-structured interviews with six chemistry teachers as participants in this study. The results of the interview are transcribed to Microsoft word. Then, the transcription results are reduced to themes through a coding process and finally present data in the form of discussion [21]. The following are the results of the data analysis conducted:

3.1 Knowledge of multiple representations in chemical concepts

A few years ago researchers proposed that the concept of chemistry can be explained with three levels of component representation, namely; macroscopic, sub-microscopic and symbolic [3][4][5]. Macroscopic representation is a representation that presents the concept of chemical phenomena in a real and visible way. Sub-microscopic representations at the atomic and particle level, and symbolic representations are representations that present chemical phenomena using chemical formulae, mathematical formulae, reaction equations, graphs, and chemical symbols. In this regard, researchers asked each participant about their knowledge of multiple representations in chemistry learning. The following are the results of the interviews conducted by researchers with each participant;

P1: Multiple representations? What is it? I don't know about multiple representations?
P2: I don't know yet. What are multiple representations?
P3: When viewed from the sentence, Multiple and Representation. multiple means multi or more than one. Then representation means to show or show. Hmmm maybe have more than one thing. But if there are multiple representations in chemistry learning, I don't know yet.
P4: What? Multiple representations? Hmm, I don't know yet, what is it?
P5: Multiple representations in chemistry? Hmm, haven't heard of multiple representation term.
P6: Multiple representations? I just heard of multiple representation term. What is it?

Based on the results of interviews conducted we can see that all participants did not know about the term of multiple representations. However, The teacher's role is also very important for student success include of knowing and understanding about representations and shifts [2]. A lot of study on multiple representations has only focused on students but not on teachers. So, it has made the teachers confused with the multiple representations. However, the researcher believes that all participants have applied several representations in chemistry learning, only the participants are not yet familiar with the term of multiple representations. Therefore, the next question that researchers asked to each participant involved examples of questions consist of multiple representation. It is aim to verify the researchers' belief that the teachers have been applied multiple representations in learning. The researchers asked to each participant that the question involved the macroscopic, symbolic and submicroscopic level. However, the researchers didn’t explain to participants about multiple representations. The following are the interview results of the question about macroscopic level;

P1: Yes, of course, at first it will show how the form of Fe has a solid phase like iron, then HCl has a liquid phase. Usually this is easily explained when doing lab work in a laboratory.
P2: Of course, Mas. This is easier to explain when conducting experiments in a laboratory. If shown directly students will be easier to understand.
P3: Yes. Usually I immediately do a mini experiment to explain to students.
P4: Of course, I would like to invite students to do a simple experiment because our laboratory availability is not enough.
The following are the interview results of the question about symbolic level;

P1 : Yes, of course. I will show students how the reaction equation occurs between Fe and HCl.

P2 : Of course.. I will explain the equation of the reaction that occurs between Fe reacted with HCl to produce FeCl.

P3 : Of course, in the reaction process between substances, the equation of reaction has become the main thing to be explained.

P4 : Of course, in learning chemistry the equation of reaction may be said to be a general one, which students must know.

P5 : Of course, in learning chemistry the equation of reaction may be said to be a general one, which students must know.

P6 : Yes, in explaining a reaction, the equation of reaction is very necessary because it is a concept students must know.

The following are the interview results of the question about sub-microscopic level;

P1 : Not yet, it’s not as detailed as the particle level. It is because there are no learning media that I use that contain content like that.

P2 : I explained that the process is just like Fe which releases 2 electrons and then is captured by 2 electrons H. However, to explain the reaction at the particulate level, I have not explained. this is due to the inadequate availability of media.

P3 : I only explained limited to the reaction equation, then the process of release and capture electron between atoms, and the equalization of the reaction

P4 : As for details like at the particle level, I haven’t explained it. However, if a concept such as release and capture electron handover is already done.

P5 : Not yet detailed at the particulate level, my explanation is only limited to the equation of reaction, then the completion and release of electrons. To explain to the particle level, I think it requires appropriate learning media.

P6 : Not yet. I have not explained at the particle level. I just explained that Fe will release 2 electrons which will then be captured by H to form H2.

The three questions above are questions that aim to explore multiple representations that have been applied by each participant to students in chemistry learning. The first question is a question related to macroscopic representation. Macroscopic level is a representation related to chemical phenomena can be seen directly by students [3][4][5]. The second question is a question relating to symbolic representation. Symbolic level is a representation related to chemical phenomena such as the use of chemical formulas, mathematical formulas, reaction equations, graphs, and chemical symbols [3][4][5]. The third question is a question relating to submicroscopic representation. Sub-microscopic level is a representation that is related to atoms or molecules at the particle level [3][4][5].

The results of the interviews show that all participant have been applied multiple representations in chemistry learning, only the teacher is not yet familiar with the term, so when researchers ask about the term multiple representations in chemistry learning, the teacher looks confused by the term. Then, based on the results of interviews, we can see that the macroscopic and symbolic representations are the level of representation applied by each participant in learning, while the submicroscopic level is still not applied. Chemical representations at the macroscopic and symbolic levels are the most emphasized representations over the submicroscopic level at both high schools and universities [23][24]. However, submicroscopic level is an important level in studying chemistry [12]. Therefore, the process of learning chemistry needs to show a conceptual relationship between representations at the macroscopic, submicroscopic, and symbolic levels in a problem-solving or inquiry. context [13].
3.2 Multiple representations applied by teachers in the classroom

The researcher explains to each participant about the term of multiple representations in chemistry learning. It aims to understanding of participants about multiple representations in learning chemistry. After each participant knows about multiple representations in chemistry learning. The researcher continues the interview by asking multiple representations that have been applied by each participant in learning. The following is a summary of the results of the interviews summarized in Table 2:

| Participant | Macroscopic | Sub-microscopic | Symbolic |
|-------------|-------------|-----------------|----------|
| P1          | √           | -               | √        |
| P2          | √           | -               | √        |
| P3          | √           | -               | √        |
| P4          | √           | -               | √        |
| P5          | √           | -               | √        |
| P6          | √           | -               | √        |

Table 2. Multiple Representation Applied by Participant

Based on Table 2, we can see that multiple representations applied by each participant are limited to macroscopic and symbolic representations. Meanwhile, sub-microscopic representation is still rarely applied by participants in learning. According to some participants this is caused by the unavailability of learning media based on multiple representations to assist teachers in explaining concepts. The following are the state of some participant.

**P1**: I think macroscopic and symbolic representation. Meanwhile submicroscopic representation requires a learning media that contains explanations at the particle level.

**P2**: In my opinion, it is at the macroscopic level of symbolic and mathematical representation. Meanwhile at microscopic representation, it is still rare. In my opinion, a learning media is needed so that submicroscopic representation is also involved in learning chemistry.

**P6**: Hmmm, symbolic is the representation most often applied. At macroscopic representation, I explain when I give an example with everyday life. Meanwhile for submicroscopic representation requires suitable media for explanation at the particle level.

In learning process, the teacher role has a very important to help understanding chemistry completely, include of shifting all levels. However, there is still a lack of scientific studies related to teacher training to help students fully understand chemistry, especially in terms of understanding shifts between all levels of representation [2]. To understand chemistry macroscopically, sub-microscopically and symbolically as well as shifting each level is not easy. There may be some students who are able to understand chemistry completely, but there are still many students who do not understand chemistry completely. To help students, the teachers must improve and vary the methods and media for used. It aims to achieve understanding for each student. Several previous studies mentioned that the use of multimedia learning can help teachers explain all levels of representation in chemistry. Such as researcher that creating three-dimensional animation with technological tools can help students learn to use microscopic and symbolic representations to explain chemical processes [25], the use of The VisChem Learning Design can effectively communicate key features at particle levels and it can link macroscopic levels to symbolic levels [16], and the use of eChem can help students understand and interpret all levels of representation [17]. Other researcher use of 4M:CHEM (Multimedia and mental models in chemistry) in learning chemistry shows students' understanding of the nature of chemical equilibrium systems [26]. Although multimedia can help teachers in the learning process, but the knowledge and ability of teachers to help students cannot be replaced by technology [2]. Therefore, teachers must always be trained to innovate in learning chemistry, especially funding multiple representations and each level in the concept of chemistry.
4. Conclusion
Based on the results and discussion of this study, all participants were not yet familiar with the term of multiple representations in chemistry learning. So, it is make all participants confused with the multiple representation. Actually, the all participants have been applied multiple representations in chemistry learning. Only, the multiple representation in learning chemistry are not yet known by participants. Multiple representations that have been applied by each participant in chemistry learning are only limited to the level of macroscopic and symbolic representations. Meanwhile the sub-microscopic level is still rarely applied by teachers in learning chemistry. It is due to the learning media or learning resources used by teachers more dominant at the level of macroscopic and symbolic representation only. The researcher hopes for the next researchers who study about multiple representations to involve teachers in studying chemistry learning based on multiple representations. The teacher has an important role in helping students to understand completely chemical concept.

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