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The Nature of the Metaconceptual Processes of Students During the Implementation of Metaconceptual Teaching Activities

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Abstract

According to Albert Einstein, the essential aim of education is "to produce independently thinking and acting individuals". What are the means to satisfy the above aim? Metacognition and conceptual change lie at the heart of the answer of this question and of this study. Since metacognition gains importance in science curriculum currently and since it was reported that metacognition facilitated conceptual change learning, the need for the studies investigating the nature of the metaconceptual processes could be easily understood. Therefore, the purpose of this study is to portray the nature of metaconceptual processes that students engage in during the implementation of Metaconceptual Teaching Activities. In this study, case study design was used. The metaconceptual teaching activities were implemented in a 10th grade chemistry classroom consisted of 30 students. The data were collected from all of the students; however, in order to explore students' nature of metaconceptual processes during treatment, two students were selected by using intensity sampling. Several types of instructional activities such as poster drawing, journal writing, group and class discussion were implemented. These instructional activities provided an opportunity for the students to become aware of their existing conceptions, to make reference to their past ideas, to monitor their understanding of a new conception, and to evaluate their conceptions. During the implementation, the science subject related to states of matter was covered as a part of the regular classroom curriculum in the Chemistry course. In order to examine the nature of students' metaconceptual processes, the data were collected from multiple sources such as journal writings, posters, audio recordings of group discussions, and video recordings of classroom discussions. The data belonged to the two students were transcribed and analyzed based on Creswell's six generic steps. Trustworthiness of the study was provided by ensuring Lincoln and Guba's four criteria: credibility, transferability, dependability, and confirmability. In this study, it was found that the students displayed evidence that they engaged in the components of metaconceptual processes which are metaconceptual awareness, metaconceptual monitoring, and metaconceptual evaluation as Yuruk indicated. It was also documented that metaconceptual processes had three fundamental features as documented in the literature. First, metaconceptual processes are multi-faceted and interdependent. Secondly, engaging in metaconceptual processes does not guarantee to have scientifically correct ideas. Lastly, metaconceptual processes had different sophisticated levels. The most sophisticated one is metaconceptual evaluation since to achieve metaconceptual evaluation requires being metaconceptually aware of one's ideas and having the ability to monitor a new concept /existing conceptions. This study is important in the field of education in terms of students' science learning, teaching strategies, curriculum development, and teacher education. This study informs teachers, teacher educators, and curriculum developers about how to implement metaconceptual teaching instruction in order to provide students opportunities to be aware of their current and existing ideas, monitor their ideas and a new concept, and evaluate their ideas for facilitating conceptual change.

1. Introduction

According to Albert Einstein, the essential aim of education is "to produce independently thinking and acting individuals" [1, p. 34]. What are the means to satisfy the above aim? Metacognition and conceptual change lie at the heart of the answer of this question and of this study. Conceptual change research has remained a significant research area in science education over the past several decades based on the foundations of constructivist learning. Researchers agreed that metacognition was an essential element underlying conceptual change models [e.g., 2, 3, 4]. The term "metacognition" was first introduced by John Flavell based on his study of metamemory in the early 1970s. Due to the multidimensional character of metacognition, different definitions [5, 6] of metacognition have been emerged in the literature. For example, Flavell [6] defined metacognition as "knowledge and cognition about cognitive phenomena" (p. 906). Many categorizations of the components of metacognition were

proposed by researchers [6]. For example, according to Flavell [6], the components of metacognition consisted of "metacognitive knowledge" and "metacognitive experience". Thorley [7] made a distinction between the terms "metacognition" and "metaconceptual" in that he considered that metacognition was more inclusive term and subsumed metaconceptual and metaconceptual included metacognitive knowledge and processes acting on a learner's conceptual system. Taking the categorizations of metacognition and the difference between metacognition and metaconceptual into consideration, Yuruk [8] proposed a different categorization for metacognition. She categorized metaconceptual knowledge and processes into four components: metaconceptual knowledge, metaconceptual awareness, metaconceptual monitoring, and metaconceptual evaluation. In this study, Yuruk's [8] categorization of metaconceptual knowledge and processes served as a theoretical stance in developing metaconceptual teaching activities. Since metacognition gains importance in science curriculum currently [1] and since it was reported that metacognition facilitated conceptual change learning [2, 5], the need for the studies investigating the nature of the metaconceptual processes could be easily understood. Taking all these issues into consideration, the purpose of this study is to portray the nature of the metaconceptual processes that students engage in during the implementation of Metaconceptual Teaching Activities (MTA). The MTA was used in states of matter unit of 10th grade high school students. States of matter is one of the crucial subjects in chemistry, and thus, it is the focus subject of this study. In the literature, there is only one study portraying the nature of metaconceptual processes of students [8]. Further research needs to be carried out in order to understand the nature of students' metaconceptual processes clearly. This study focuses on the following research question: "What is the nature of the metaconceptual processes that students engage in during the implementation of Metaconceptual Teaching Activities (MTA)"?

2. Design

In this study, case study design was used. The metaconceptual teaching activities were implemented in a 10th grade chemistry classroom consisted of 30 students (17 females and 13 males). In order to examine the nature of students' metaconceptual processes, the data were collected from multiple sources such as journal writings, posters, audio recordings of group discussions, and video recordings of classroom discussions. The data were collected from all of the students; however, in order to explore students' nature of metaconceptual processes during treatment, two students (Erin and Serra) who had several alternative conceptions were selected. These two students were selected based on their pre-instructional States of Matter Diagnostic Test (SMDT) scores and the teacher's and researchers' observations. The SMDT developed by the researchers is a 19-item three-tier diagnostic test consisting of three tier items for assessing students' understanding of states of matter concepts. Cronbach alpha reliability index was found to be .78 in the pilot study. It should be noted that it was assumed that the SMDT scores represented the range of students' alternative conceptions. The students who got low and high scores from the SMDT had several and few alternative conceptions, respectively. Erin and Serra, were selected among the students who had low scores on the pre-SMDT. Both of them scored 1 out of 19. The students who had a wide range of alternative conceptions were the focus of this study since it would be helpful to track metaconceptual processes of students during implementation, while students were changing their alternative conceptions with the scientific concepts. Purposeful sampling was used to identify the students who were the focus of the study. The students were selected by intensity sampling. In this study, only Erin's nature of metaconceptual processes is exemplified since it would be too loaded to give metaconceptual processes of the two students as case studies. Before the study commenced, the students were given the SMDT to examine their pre-instructional understanding of states of matter concepts. In order to facilitate students' engagement in metaconceptual knowledge and processes several types of instructional activities such as poster drawing, journal writing, group and class discussion were employed. The implementation lasted for seven-week. These instructional activities provided an opportunity for the students to become aware of their existing conceptions, to make reference to their past ideas, to monitor their understanding of a new conception, and to evaluate their conceptions. Qualitative data analysis was performed in this study. In this study, only the data belonged to the two students were transcribed and analyzed based on Creswell's [9] six generic steps. Trustworthiness of the qualitative study was provided by ensuring Lincoln and Guba's [10] four criteria: credibility, transferability, dependability, and confirmability.

3. Results and Conclusion

In this study, it was found that the students displayed evidence that they engaged in the three main components of metaconceptual processes which are metaconceptual awareness, metaconceptual monitoring, and metaconceptual evaluation as Yuruk [8] indicated. In metaconceptual awareness, students make reference to their elements of conceptual ecology either they already had or currently possess. Researchers indicated the crucial role of metaconceptual awareness in conceptual change learning [5]. Vosniadou [e.g., 5] stressed the importance of metaconceptual awareness of one's own internal inconsistencies in order to avoid synthetic models. Throughout the MTA, the students were provided opportunities to engage in metaconceptual awareness. For example, Erin displayed evidence that she became aware of everyday applications of a topic during her engagement in journal writing activities. In a Journal Writing Activity, the students were posed the following questions: "According to you, why do we learn Charles's Law? How does Charles's Law help you in everyday life?" Erin answered that "I left a balloon in the cold for a long time and I found that it was shrunken, and now I understand why I found it like that". In this study, the students also displayed evidence for their engagement in metaconceptual monitoring. When students encounter a new conception or ideas from other people/sources, they engage in metaconceptual monitoring. Several researchers stressed the importance of metaconceptual monitoring in conceptual change [2]. Hewson and Thorley [2] emphasized the importance of monitoring the status of learners' own conceptions/concepts in effective conceptual change teaching. In a class discussion, Erin monitored her understanding of chemical bonding which was an example for metaconceptual monitoring understanding of an idea. She emphasized that the bonding between the hydrogen and oxygen atoms in the molecule itself was not affected at evaporation. She added that the bonding between the two water molecules which was called hydrogen bonding was broken. Metaconceptual evaluation was the most sophisticated level of metaconceptual processes and included metaconceptual awareness and metaconceptual monitoring since there is a hierarchy among them as discussed below. Metaconceptual evaluation is the essence of conceptual change learning/teaching [2, 5]. The students engaged in metaconceptual evaluation during the MTA. Erin made judgmental comments on the plausibility and fruitfulness of past or new ideas while engaging in metaconceptual evaluation. For example, in a group discussion related to evaporation, Erin showed evidence that she engaged in metaconceptual evaluation of existing idea. The following explanation of Erin showed that Erin was making comments on the plausibility of her existing idea although it was not scientifically correct: "But hydrogen and oxygen separated from each other and turns into gas at evaporation. If they stay as water molecule, then, it is not possible for them to turn into gas because oxygen and hydrogen are gases. Certainly, they separated from each other". However, after Erin monitored the consistency between her existing idea and ideas from her friends in the group and class discussion, she changed her mind which corroborated the study of Hewson and Thorley [2] who emphasized the importance of monitoring the status of learners' own conceptions in effective conceptual change teaching. Erin stated that she thought the bonding between the hydrogen and oxygen was broken at the evaporation of water. However, after her friends stated that evaporation is a physical change and if the bonding between the hydrogen and oxygen was broken, it would be chemical change, then, Erin evaluated the validity of her friends' idea and changed her mind. In this study, it was seen that metaconceptual processes had three fundamental features. First, metaconceptual processes are multi-faceted and interdependent as reported elsewhere [5, 8]. This means that metaconceptual processes include different types of processes such as metaconceptual awareness, metaconceptual monitoring, metaconceptual evaluation and their subcomponents. Also, engagement in metaconceptual evaluation requires having ability to engage in metaconceptual awareness and metaconceptual monitoring, or engagement in metaconceptual monitoring means that one is aware of her/his ideas, but, this does not mean that to be able to engage in all subcategories of these metaconceptual processes. Secondly, engaging in metaconceptual processes does not guarantee to have scientifically correct ideas as discussed above. Thirdly, metaconceptual processes had different sophisticated levels as Yuruk [8] declared. The most sophisticated one is metaconceptual evaluation since to achieve metaconceptual evaluation requires being metaconceptually aware of one's ideas and having the ability to monitor a new concept /existing conceptions. This study informs teachers, teacher educators, and curriculum developers about how to implement metaconceptual teaching instruction in order to provide students opportunities to be aware of their current and existing ideas, monitor their ideas and a new concept, and evaluate their ideas for facilitating conceptual change. Since metacognition lies at the heart of conceptual change, it is crucial to know the nature of metaconceptual processes of the students. Further research needs to be carried out in order to understand the nature of students' metaconceptual processes clearly.

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