EURASIA Journal of Mathematics, Science and Technology Education, 2019, 15(8), em1737
ISSN:1305-8223 (online)
Research Paper https://doi.org/10.29333/ejmste/105275

Using a Discrepant Event to Facilitate Preservice Elementary Teachers' Conceptual Change about Force and Motion

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Received 10 November 2018 ▪ Revised 5 February 2019 ▪ Accepted 4 March 2019

ABSTRACT

Both students and teachers have misconceptions about Force and Motion, often caused by teachers not being well-prepared to teach the accepted scientific theory. Besides, teachers rarely or never use a cognitive conflict strategy in their teaching. The present study is aimed at investigating the use of a discrepant event to facilitate preservice elementary teachers' conceptual change on Force and Motion concepts. The main objectives were to (1) investigate conceptual changes in Force and Motion concepts and (2) track students' conceptual change and their learning progression of these concepts. The research method used an intervention with a mixed method design. Second-semester students (N=120) participated in this study. The research instrument consisted of background information of respondents and their belief of conceptions about Force and Motion. The preliminary study using Direct Instruction and discussion methods. Once students' conceptual change profiles were known, remedial teaching was conducted through Reflective Conceptual Change Model-assisted Visual Multimedia. The research findings have shown that a discrepant event could help participants engage in conceptual change and have better explanations than before. The profile of their conceptual change and pattern of learning progression are discussed.

Keywords: discrepant event, conceptual change, learning progression, force and motion

INTRODUCTION

When learning science, students need guidance to improve their everyday knowledge and previous concepts: their understanding of the universe can be a barrier in obtaining scientific conceptions during science learning (Mortimer & El-Hani, 2014). However, teachers sometimes are not well-prepared to teach the accepted scientific theories (Halim, *et al*., 2014). As a result, students' understanding tends to rely on intuition and tactile experiences (Galili & Bar, 1997; Vicovaro, 2012, 2014).

Studies on the understanding of science in some countries such as Australia, USA, South Korea, South Africa, and Taiwan indicate that most students are in the *'inadequate understanding'* category (Kang *et al*., 2004; Liu & Lederman, 2007). The understanding plays an important role in decision-making in daily life, determining the right choices in *socio-scientific issues*, as well as a deep comprehending science and its application (Bayir, Cakici & Ertas, 2014; Matthews, 2000; Lederman, 1992; Sormunen & Koksal 2014). Additionally, understandingthe nature of science is an important part of scientific literacy (Abd-El-Khalick, Bell, & Lederman 1998; Bell & Lederman 2003; Lederman, 2007; Lederman & Lederman, 2014; Mulvey *et al*., 2016; NGSS Lead States, 2013; Seung, Bryan & Butler, 2009) which is one of the main purposes of science education (Lederman & Lederman, 2014; Sorensen, Newton & McCarthy, 2012).

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Contribution of this paper to the literature

- This study contributes to the existing literature on students' conceptual change about force and motion.
- Unlike the previous literatures that tended to focus on the initial and final stage of students' conceptions, by employing the learning progression strategy this study provides a detail and step by step of the changes of students' conceptions.
- This detail information on should help teachers to develop a better teaching strategies to facilitate students' learning. This study also offer new strategy for other researchers in doing research on conceptual change and learning progression.

Many students and teachers do not have a correct understanding of scientific concepts (Halim *et al.*, 2014). In fact, in several studies, students and teachers have the same naive conceptions (Abd-El-Khalick *et al.*, 1998; Dogan & Abd-El-Khalick, 2008). This finding may be caused by elementary teachers who are not prepared to teach science according to accepted scientific theories (Halim *et al.*,2014). According to the theory agreed upon by scientists, in the absence of other forces acting on objects that move on the earth, the motion of objects is only influenced by the force of gravity so that each object will fall almost simultaneously. But the results of previous studies (Allen, 2010; Anggoro, et al., 2017; Bani-Salameh, 2017; Bayraktar, 2009; Vicovaro, 2012, 2014) show that most students have misconceptions, namely that when dropped simultaneously, heavier objects arrive at the base first than light objects.

Scientific Concepts and Misconceptions about Force and Motion

When objects are stationary or in a stationary position, theoretically there is a force acting on the object with the resultant force equal to zero. Thus, for each action style carried out there is always a reaction force of the same magnitude but the direction is the opposite or the interaction style between two objects is always equal but the direction is opposite. But some previous studies (such as Allen, 2010; Anggoro, et al., 2017; Darling, 2012; Minstrell, 1982) show that some students have misconceptions, that in a stationary object there is no force at work.

In the view of scientists, an object or material will float or sink depending on the ratio of its density to the density of water and the surface area of objects in contact with water. An object is said to float when the object is on the surface of the water because the density/density of the object is smaller or equal to the density of water. An object can be said to sink if the object drops to the bottom of the water because the weight of the object is greater than the density of water. But the results of previous studies (such as Kaltakci & Didi, 2007; Libarkin, et al., 2003; Potvin & Cyr, 2017; Tasdere & Ercan, 2011; Unal, 2008; Yin, et al., 2008) show that students experience misconceptions that the sinking or floating of an object is influenced by the mass and shape of the object.

Every particle in this universe will experience the attraction with one another. The magnitude of the attraction is directly proportional to the mass of each object and inversely proportional to the square of the distance between the two. This phenomenon is the Universal Law of Gravity. When the earth gives an action force in the form of gravitational force to other objects, then the object gives a reaction force that is equally large but opposite to the earth. Because the magnitude of the action force and reaction are the same, the magnitude of the gravitational force must also be proportional to the mass of two interacting objects. But most students have a misconception that gravity is only possessed by the earth so that objects in space will hover (Bayraktar, 2009; Lemmer, 2017; Millham & Isabelle, 2013; Minstrell, 1982; Sadanand & Kess, 1990; Temiz & Yavuz, 2014). A study by Anggoro, Widodo and Suhandi (2017) showed that most pre-service elementary school teachers had a misconception of the concept of force and motion such as (1) the speed of a falling object is affected by the weight of the object; (2) there is no earth gravity in the outer space; (3) all objects heavier than water will drown in water; and (4) there is no working force against a stationary object.

The misconception about science is often experienced by students at all levels of education (Anggoro, Widodo & Suhandi, 2017; Beck-Winchatz & Parra, 2013; Hamid, *et al.*, 2017; Hermita *et al.*, 2018; Kang *et al.*, 2004; Lederman, 1992; Lederman *et al.*, 2002; Lederman & O'Malley, 1990; Seung *et al.* 2009). One of the reasons is that the majority of teachers in both primary and secondary school seldom or even do not deliver a correct understanding of science in the learning process. In fact, the results of a study on the education of preservice teachers showed the same conclusion (Abd-El-Khalick *et al.*, 1998; Liu & Lederman, 2003). The teachers' understanding of the essence of science is also not visible in the learning process in the classroom (Abd-El-Khalick & Lederman, 2000; Herman *et al.*, 2013; Herman & Clough, 2016; Kurup, 2014; Lederman, 2007). Meanwhile, the success of the learning process of science is determined by the teachers' understanding of the essence of science (Akerson & Hanuscin, 2007; Wahbeh & Abd-El-Khalick, 2014).

Conceptual Change

Vosniadou and Ionanides (1998: 1203) and Limon (2001) stated that learning science is a gradual process during which an initial conceptual structure based on children interpretations of everyday experience are continuously enriched and restructured. The acquisition of science concepts is the definition conceptual change in learning in which the structure of the pre-instruction conceptual of the students become a fundamental part that is restructured in order to gain a higher understanding of knowledge (intended knowledge). Thus, conceptual change is the learning pathways of students' pre-instructional conceptions to become scientific concepts (Duit, 1999).

Learning is an active process of constructing knowledge, resulting in a "*change in learning conception.*" The activity is defined as a *conceptual change* (Duit, Widodo & Wodzinski, 2007). When building *pre-instructional conceptions* that are not in accordance with the concept to be learned, then the learning is seen as a change to the *preconception* (Driver, 1989; Widodo, 2004). The initial knowledge is not only the starting point of the learning process but also as a guide in the learning process (Duit & Treagust, 1998).

There are two ways or processes to change pre-conceptions into scientific conceptions, namely continuous and discontinuous pathways (Duit, 1999). Discontinuous pathways utilize cognitive conflicts that challenge the learners' *preconception* because it is very different from the scientific conception. There are two strategies of conflict that can be used: first, the learners are asked to make predictions about a concept and then it is compared with the results of observations or *events,* and second, provide a challenge for the learners to maintain the *preconception* that they have with other learners or teachers (Widodo, 2004: 30). Posner *et al.* (1982) and Hewson (1992) stressed that the decision regarding the *conceptual status* and *conceptual changes* is derived from the learner, not the teacher. This is in line with the constructivist learning theory and is a *highly personal nature* of *mental model* (Duit, Treagust & Widodo, 2013; Norman, 1983).

There are several learning strategies that can be used to gain *conceptual changes* such as cognitive conflict (Kang *et al,* 2004, 2005, 2010; Limon, 2001; Pintrich, 1999; Pintrich & Sinatra, 2003), metaphors (Amin, 2009; Lakoff & Johnson, 1980; Niebert & Gropengiesser, 2015), concept maps (Moore, 2013; Novak, 1990; Novak & Cañas, 2008; Novak & Gowin, 1984), and analogies (Davies, 2014; Gentner, *et al*., 1997; Glynn, 1991; Kuhn, 1977). Cognitive conflict is a learning strategy that can be used to obtain *conceptual changes* (Kang *et al*., 2004, 2005, 2010; Limon, 2001; Pintrich, 1999; Pintrich & Sinatra, 2003). Cognitive conflict or conceptual conflict is a learning strategy that begins with the discoloration process of their confidence through contradictory learning experiences that allow students to replace the misconceptions with the scientific conception (Hadjiachilleos *et al,* 2013; Kang *et al,* 2010; Limón, 2001). This strategy is effective in correcting misconceptions and improving students' performance (Ab Rahim, Noor & Mohd Zaid, 2015; Druyan, 2001; Limon, 2001; Skoumios, 2009). In such conflict situations, the learners' minds will be imbalanced (disequilibrium). Hence, it will be easy for educators to change the initial conception—that may be misconception—into the scientific concept (Widodo, 2004: 30). This situation is in line with Posner *et al.* (1982), that conceptual change begins with dissatisfaction or when ideas are unbalanced.

Discrepant Events

The presentation of *discrepant events* or *anomalous data* is the first step in the process of *conceptual change* in the cognitive conflict learning strategy (Chinn & Brewer, 1993, 2001; Kang *et al*., 2010; Toplis, 2007; Vosniadou, 2014). Scientists and engineers use *discrepant events* to develop new interpretations that lead to a new conceptualization and finally, to the profound conceptual change (Limon & Carretero, 1997). In addition, the presentation of *the discrepant event* is an important step in the process of *conceptual change* (Chinn & Brewer, 2001; Vosniadou, 2014). Scientists used it to build a new interpretation of a concept to obtain a deep conceptual change (Limon & Carretero, 1997; Toth, 2016). Furthermore, the scientists' reaction towards it is basically identical to the way of thinking of adult nonscientists as well as students learning science while analyzing the data (Chinn & Brewer, 1993; Toth, 2016). In fact, the use of discrepant event responsibly and accurately in researches and practices in the field is paramount (Drenth, 2006; Martinson *et al*., 2005; Masnick & Klahr, 2003; NGSS, 2013).

The awareness about the discrepant event is the next step of the conceptual change process in the cognitive conflict strategy. It includes setting the types of responses to the anomalous data from the least acceptable to the most acceptance (Chinn & Brewer, 1993; Hadjiachilleos *et al*., 2013; Kang *et al*., 2010; Lee & Kwon, 2001; Lee *et al*., 2003; Limon & Carretero, 1997). The level or type of response to the anomalous data has been studied by many experts including Piaget (1975), Hewson and Hewson (1992), Chi (1992), Chinn and Brewer (1993, 2001), Vosniadou (1994), Limon and Carretero (1997), Lee and Kwon (2001), and Hadjiachilleos *et al.* (2013). The researchers' responses are divided into three groups.

In the first group, the response was stated by Piaget (1975), that divided the responses into unadapted and adapted responses and they consist of four levels of response, namely, unawareness of contradiction, alpha, beta, and gamma. The second group that stated Chinn and Brewer's (1993, 2001), which is supported by studies conducted by Lee and Kwon (2001), Lee *et al.* (2003), Kang *et al.* (2010), and Hadjiachilleos *et al.* (2013). There are eight types of responses ranging from ignored to *change theory.* The third group was argued by Limon & Carretero (1997), which is supported by the studies by Hewson and Hewson (1992), Chi (1992), Vosniadou (1994), and then followed by Toplis (2007) and Toth (2016). They explained that there are four levels of conceptual change, that is no conceptual change but awareness of contradiction, no conceptual change but awareness of contradiction, weak restructuring, and strong restructuring.

Learning Progressions

Learning progressions have become an important process in research on constructivism, conceptual change, and scientific reasoning (Furtak, 2012; Henry, 2014; Smith *et al.,* 2006). From the cognitive perspective, students will construct mental models and schemes, and organizational learning strategies and frameworks through interactions of learning and reasoning. In the sociocultural perspective, both of which are cultural resources, and students are eager to participate in authentic activities that use both of them to learn effectively (Bruner, 1966; Cole & Wertsch, 1996; Hubber, 2010; Piaget, 1969; Tytler *et al.,* 2009; Waldrip, Prain & Carolan, 2010; Vygotsky, 1978).

Learning progressions have become increasingly important tools in science learning today. Theories have developed along with the rampant usage of learning progressions in identifying and validating students' understanding of science. In addition, many studies have shown that with learning progressions, students' progress can be tracked accurately so that it gives a positive impact on the learning of science (Corcoran, Mosher & Rogat, 2009; Dyer, 2013; NRC, 2007). The output of the learning progressions is the map of changes in students' cognition when studying a concept (Shavelson, 2009). Unlike teaching the theory of science, the learning progression focuses on the students' ideas. These are increasingly sophisticated sequences of ways of thinking and reasoning that students use to understand the real world. Therefore, it will significantly be more effective in guiding the learning process of science in schools (Jin, Zhan & Anderson, 2013).

Learning progressions can be used to describe the students' progress from the pre-conception to the scientific conception (Duncan, Rogat & Yarden, 2009). Additionally, these are useful for designing effective instructional materials, designing formative and summative assessment, and supporting the learning process that helps students *meaningfully engage* the concepts and practices of science from time to time (Schwarz *et al.,* 2012: 102), through appropriate learning processes (Corcoran, Mosher, & Rogat, 2009).

Building an effective learning model should start by identifying difficulties and misunderstandings delivered by students (Halim *et al.,* 2009). The purposes of this study are to (1) identify the preconception profile of preservice elementary school teachers about some of the essential concepts of object motion in free fall, and (2) map the *conceptual changes* and *learning progressions* based on participants' explanations during their learning.

In Indonesia, the concept of force and motion has been taught since 4th-grade elementary school to college. This concept is part of The Law of Motion which has been the subject of research since Aristoteles (384 BC). The concepts of free fall, rest objects, buoyancy, and gravity are related to the Second Newton's Law of Gravity and the Third Newton's Law of Action-reaction Forces. These four concepts are interactions of basic concepts of mechanics such as gravity, normal force, drift force, mass and weight, acceleration and speed. Based on literature studies, it is known that students' and teachers' have misconceptions about the four concepts of mechanics because these concepts are abstract, so students tend to rely on intuitive and/or tactile experience (Galili & Bar, 2001; Vicovaro, 2012).

The concept of force and motion, such as free fall, gravity, buoyancy force, and the action-reaction force, is the basic building blocks in learning physics (Young & Freedman, 2006) and is one of the key concepts in science literacy (Christensen *et al.,* 2014). This study identified the profile of preconceptions and conceptual change of the concepts of motion of objects in free fall, the earth's gravity, action-reaction forces, and buoyancy forces that occur during learning using a strategy of cognitive conflict and patterns of conceptual change and learning progression which occur during the learning process.

MATERIAL AND METHODS

Methods

The research used an Intervention Mixed Methods Design (Creswell, 2013) which uses two research methods. The qualitative method was used to identify misconceptions experienced by students and the alternative strategy in reconstructing students' conceptions in the Basic Science Concept 2 course, especially concepts related to Force and Motion. The quantitative method was used to get an overview of the effectiveness of reconstruction conception using cognitive conflict strategy, in the form of conceptual change and learning progressions that occur in remedial teaching about Force and Motion.

Participants

One hundred and twenty students at first grade undergraduate of elementary teacher training study program were participants in this study. They were chosen because they had graduated from high school but have not taken the Second Science Basic Concept courses. One hundred and six students were female and the rest were male. Fifty-one students have the educational background of Science (either from high school, Vocational Engineering, or Madrasah Aliyah (Islamic high school)), and the rest were non-Science (Social Studies, Languages, and Vocational Economics and Administration). The participants were chosen based on the diversity of high school background of preservice elementary school teachers. They were students taking the Basic Concept of Science course with the focus on physics studies.

In order to see changes in participants' conceptions (level of conceptual change and learning progression) about free fall, remedial teaching was used with 32 elementary school teacher candidates consisting of 16 participants from science in high school background and 16 ones from non-science.

Instrument

The conception test instrument that was developed to find out the conception of preservice elementary school teacher students was 7 items. Test items used the four-tier test format. The conception test validation was judged by two physics education experts and one theoretical physicist. The results of the validation of the conception test items indicated that the validator generally stated that the items to be used are valid both in content and construction. Validators provided some notes that are suggested to be revised, especially those that are considered inappropriate, that is, related to accepted scientific theory, image clarity, sentence editorial, and written order. The research instrument was in the form of several multiple-choice items on the concept of force and motion that require explanations about the selected answers. To find out the participants' *conceptual change*, they wrote their responses towards several written statements (Yes/No/Not always) and with confidence levels (Sure/Not really sure/Not sure). The participants answered the questions individually and do not include their names to ensure their anonymity.

Procedures

In the preliminary study, Direct Instruction and discussion methods were used. After knowing the conceptual change profile that occurred, then the remedial teaching was conducted. It was adopted by the *reflective conceptual change* model of Chinn and Brewer (1993) and Aydenis and Brown (2010, 2017) and the cognitive conflict process model of Lee *et al.* (2003) and Hadjiachilleos *et al.* (2013), namely The Multimedia Visual Reflective Conceptual Change Model (RCCM). This learning model covering three stages, namely pre-learning, learning process and post-learning. The pre-learning goal is to uncover the initial predictions/ conceptions of the preservice elementary school teachers related to the concept of Style and Motion through revealing puzzle questions so that interrogative sentences are used. The stages of the process include practices and reiterate. The expected goals in this stage are: (1) conducting evidence to solve phenomena or experimental results; (2) comparing the "genuineness" of the problem with their initial conception; (3) developing and evaluating conceptions scientifically; and (4) building stronger conceptions using different discrepant events. In order to support this goal, it is necessary to design visual multimedia such as video phenomena, video animation, and equipment that supports and can explain the discrepant event phenomenon. Whereas in the third stage in the form of evaluation, it aims to map learning progression and conceptual change for preservice elementary school teachers' conceptions about Force and Motion.

Before and after the learning process, students answered pretest questions that included the concept of motion of free fall, stationary/rest objects, the buoyancy force, and gravity. Their answers were accompanied by explanations or reasons for choosing the answer. Based on the evaluation of the pretest results, in the posttest, separate answers sheets were provided with the consideration to provide adequate space to express their thoughts.

The representations used include oral, written, visual, and mathematical forms (charts, tables, equations) on the concepts. The discrepant event phenomenon was created is based on four misconceptions that will be corrected, namely free fall, rest object, buoyancy, and gravity. The discrepant event for free fall includes the phenomenon of the motion of free-falling objects in a vacuum and in an open space with different shapes of objects and masses. As for the concept of rest objects using the phenomenon of books on the table and people pushing the walls. There were supported by the visual representation of several videos and animations from BBC 2 program and MIT Department of Physics (Free fall on Vacuumed and Gravity), and Appolo 15 by NASA (Free fall in outer space) Misconception and scientific conception of anomalous data were selected based on the results of previous studies and conceptual frameworks such as of Vicovaro (2014) and *the book titled* Misconception in Primary Science that written Michael Allen (2010), concerning the mass-belief belief and free fall. At this stage of building the

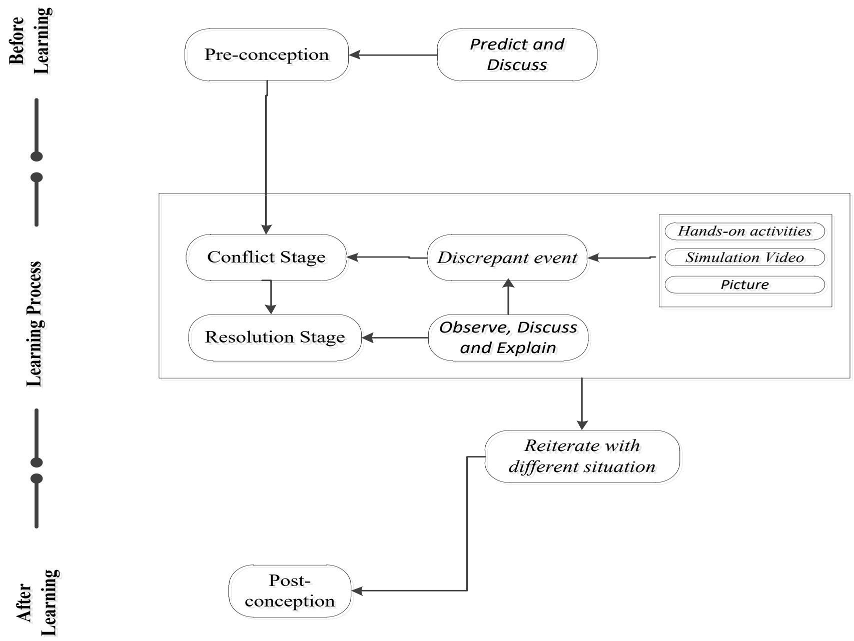

Figure 1. Remedial Teaching through Reflective Conceptual Change Model-assited Visual Multimedia

understanding and evaluating the competing theoretical explanations and building the belief of scientific conception, a different phenomen*on* was used and supported.

Data Analysis

Analysis of the results was done descriptively using percentages. The data used were quantitative and qualitative data. The quantitative data were expected to help explain or provide a basis for the obtained qualitative results. The qualitative data were used to give a complete description of the differences in cognition that occurred in students on the concept of force and motion. Quantitative data sources were obtained from differences in student cognition on pretest and posttest. These data were then classified into several types, and the qualitative data were obtained from the classifications. The classification results were then used to analyze the conceptual change and learning progression experienced by each student in order to obtain quantitative data. The quantitative results were expected to support the qualitative data of students' cognitive differences during the learning process. The answers given by the students on the pre-test and post-test was used to provide a picture of student conceptual change to the concepts investigated. In addition, the answers can also provide a picture of the learning progression that occurs during the learning process. Response categories were conducted to summarize the difference of answers given during pre-test and post-test, then classified based on the student's answer level (Kristianti, 2016). The response categories were adapted from the response model to discrepant events developed by Kaltakci-Gurel and Didis (2007) and Kaltakci- Gurel, Eryilmaz and McDermott (2015) such as scientific conception, lack of knowledge, error, and misconception.

RESULTS AND DISCUSSION

Preconception Profiles

Most participants have misconceptions of some essential concepts in science, especially students with a non-science high school background. They argued that (1) the speed of a falling object is affected by the weight of the object; (2) there is no working force against a stationary object; (3) all objects heavier than water will drown in water; and (4) there is no earth gravity in the outer space. The preconception profile of preservice elementary teachers is shown in **Figure 2**.

Almost all participants believe that the speed of falling objects influenced by the mass or weight of objects. However, there is a small percentage of participants with have science background who believe that the speed of a falling object is not affected by it. This indicates that most aspiring elementary teachers have confidence in misconceptions about the concept or misconception. Several studies (eg Anggoro, Widodo & Suhandi, 2017; Bani-

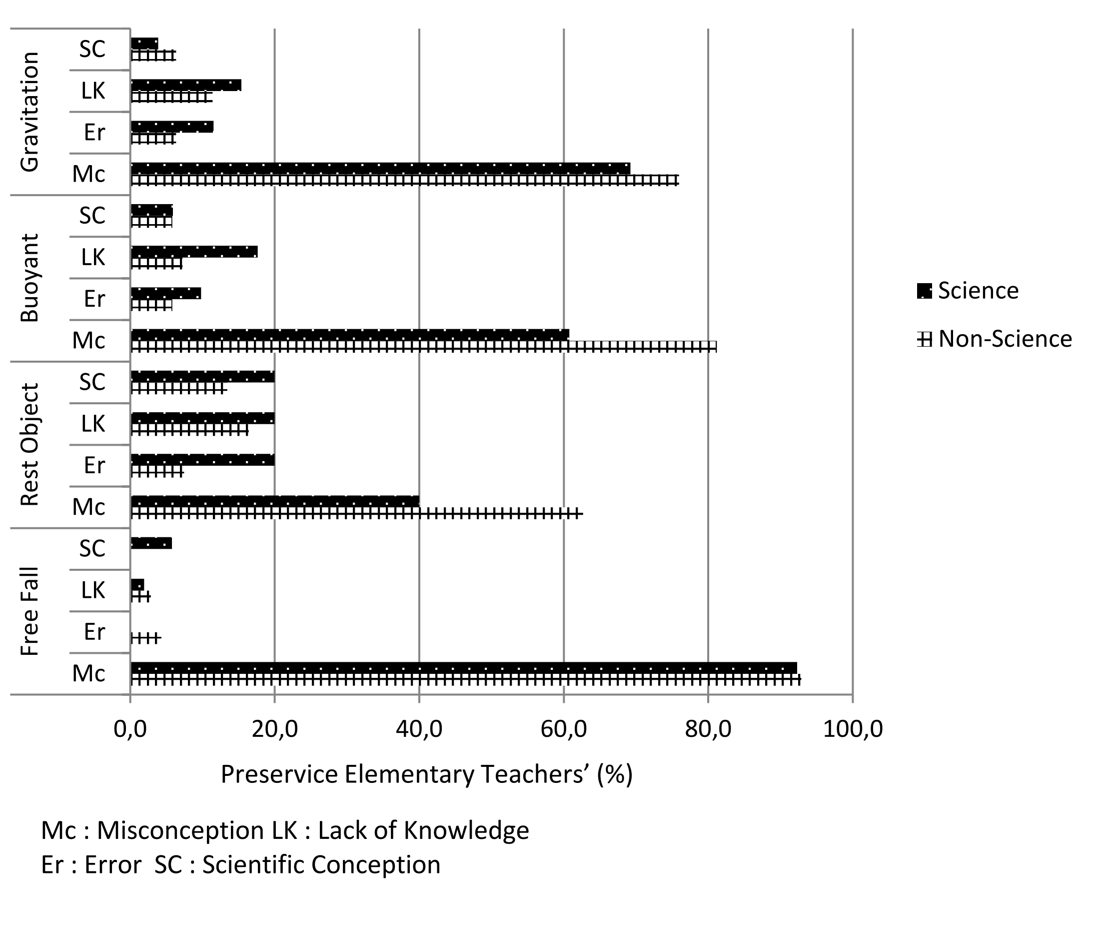

Figure 2. Preconception Profiles of Preservice Elementary School Teachers' Based on Their High School Background

Salameh, 2017; Vicovaro, 2014; Allen, 2010: 120) supported the results of this study. According to Rohrer (2002) and Vicovaro (2014), the common misconception of the free fall object motion is namely mass-speed belief.

Half of the participants believed that there is no working force against a stationary object. This result is in line with Chee (1996) who investigated that more than 50% of Physics study program students have a misconception that when objects are stationary, the friction force that occurs on the object is zero. Similarly, Allen (2010: 140) reported that the common misconception experienced by elementary students is "An object at rest has no forces acting upon it." The results of this study supported those of Anggoro, Widodo & Suhandi (2017), that one-third of primary school teachers, especially those with non-science high school background, experience the condition of no forces acting on the object.

Figure 2 indicates that most participants have a misconception about the concept that objects that are heavier than water will sink and those lighter than water will float. Several previous studies (such as Anggoro, Widodo & Suhandi, 2017; Kiray *et al*., 2015; Cepni & Sahin, 2012; Tasdere & Ercan, 2011; Allen, 2010; Unal, 2008; Unal & Costu, 2005; Yin, Tomita, & Shavelson, 2008) concluded that students, teachers, and preservice elementary teachers experienced the same misconception about the concept of floating or sinking objects in water.

Most participants have misconceptions about the concept of weight and volume. Kohn (1993) described it as the size-weight illusion. The results of this study are in line with the results of previous studies (eg Kiray, et al., 2015; Hardy et al., 2006; Duckworth, 2001; Kohn, 1993; Piaget, 1930: 164-179) which summed up the difficulty experienced by students of all ages in understanding the relationship between weight and volume of objects.

Figure 2 also indicates that three-quarters of elementary school teachers have a misconception or misconception about the concept. Several previous studies (eg Anggoro, Widodo & Suhandi, 2017; Allen, 2010; Gonen, 2008; Bulunuz & Jarret, 2010; Kikas, 2004) provides conclusions that support the results of this study.

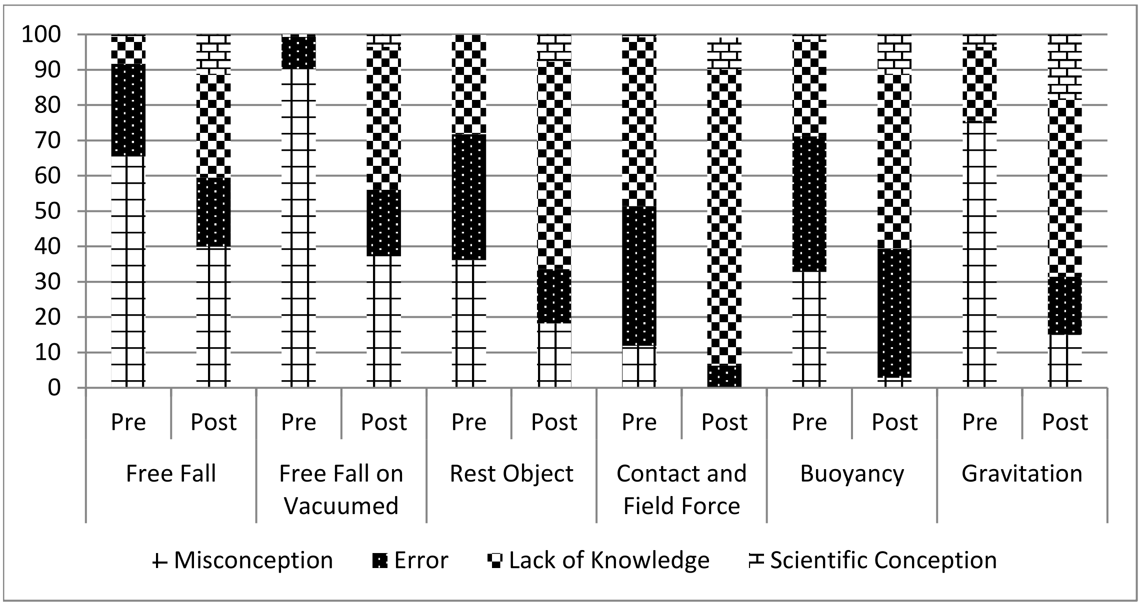

Figure 3. Conceptual Profile of Preservice Elementary School Teachers about Free Fall

Conceptual Change Profiles

The conceptual change profiles of preservice elementary teachers' before and after the learning process is shown in **Figure 3**. Prior to learning, in general, more than half of the participants have misconceptions about the concepts studied, especially on the concept of free-falling objects and gravity.

More than 30% of students actually knew the true concept of science, but that knowledge was intuitive. For example, this is indicated by their explanation that gravity affects the speed of falling objects. However, they still believed that mass also affects the speed of falling objects. Vicovaro (2014) refers to this as the intuitive physics of free fall. They believed that the concept of free-falling objects was analogous to the concept of apples falling from trees. However, these beliefs were not accompanied by their understanding of the mathematical formulas of free fall motion.

Newton's third law of action-reaction action, and contact and non-contact forces were well remembered by most participants. This is evident from the number of participants who had improper preconceptions which is below 20%. However, there are no changes in the conceptual understanding concept profile during the learning process. Some of the preservice elementary school teachers still thought that a force occurs only when things move. This is supported by the opinion of Allen (2010: 140), Eryilmas (2002), and Azman *et al.* (2013) about the misconception that occurs in learning in primary science and preservice teachers. After conducting the learning process using the anomalous data while performing the cognitive conflict strategy, the conceptual change in force and motion was indicated by the preservice elementary school teachers. Although on average, 15% of them still have *the* misconception, 42% had the synthetic conception, and 8% had the scientific conceptions. These results supported those of previous studies (such as Limon, 2001; Druyan, 2001; Skoumios 2009; Ab Rahim, Noor, & Mohd Zaid, 2015).

Conceptual Change Level Profiles

Conceptual change in science learning occurs gradually through a series of structured activities carried out continuously (Vosniadou & Ionanides, 1998: 1203; Vosniadou, 2008a, 2008b, 2014; Limon, 2001). However, preconception tends to be difficult to change (Suppapittayaporn, *et. al,* 2010; Halim *et al.*, 2014; Bani Salameh, 2017; Anggoro *et al,* 2017). With these assumptions, the development of conceptual change which occurs during the learning process using Limon & Carretero (1997) can be predicted and the results are shown in **Table 1**.

Table 1. Level of Conceptual Change of Forces and Motion Concepts of Preservice Elementary School Teachers

Degree of Conceptual Change	Free Fall	Free Fall on Vacuumed	Rest Object	Contact and Field Force	Buoyancy	Gravity
No conceptual change at all	40.4	25.5	18.2	0	2.8	15
No conceptual change but awareness of contradiction	14	11.6	20.3	37.3	40.6	15.5
Weak restructuring	35.1	59.4	53.1	54.3	46.9	54.1
Strong restructuring	10.5	3.5	8.4	8.4	9.7	15.4

Table 2. Responses to Discrepant Event about Forces and Motion Concepts by Preservice Elementary School Teachers Based on Chinn and Brewer (1993) criteria

Responses to Discrepant Event	Free Fall	Free Fall on Vacuumed	Rest Object	Contact and Field Force	Buoyancy	Gravity
Ignore	39.9	25.5	9.8	0	2.8	15
Abeyance	6.3	11.9	8.4	0	0	12.7
Reinterpret maintaining preconception	13.1	18.6	15.4	6.3	36.2	16.2
Peripheral change to target conception	29.4	40.5	57.6	84.2	49.5	50.5
Accept the data and change theory	10.5	3.5	8.4	8.4	9.8	15.4

Table 3. Responses to Discrepant Event about Forces and Motion Concepts by Preservice Elementary School Teachers Based on Piaget (1975) criteria

Responses to Anomalous Data		Free Fall	Free Fall on Vacuumed	Rest Object	Contact and Field Force	Buoyancy	Gravity
Unadapted responses	Unawareness of contradiction	39.9	25.5	9.8	0	2.8	15
Adapted responses	Alpha	19.4	30.5	23.8	6.3	36.2	28.9
	Beta	29.4	40.5	57.6	84.2	49.5	50.5
	Gamma	10.5	3.5	8.4	8.4	9.8	15.4

Table 1 indicates that the level of conceptual change using the discrepant events was highest on weak structuring. This indicates that there was a conceptual change in preservice elementary teachers but they had not reached the expected scientific concept or the target concept. This is in line with the concept of synthetic conception proposed by Vosniadou and Brewer (1992) and Vosniadou (2014).

The response to the discrepant event was identical to the occurring development of the conceptual change. **Tables 2** and **3** show that the majority of the responses towards the discrepant event on the concepts of force and motion were at the level of peripheral change to the target conception (Chinn & Brewer, 1993) or adapted responses at the beta level (Piaget, 1975), except for the concept of free fall on vacuumed and action-reaction forces. This is in line with the research results of Vicovaro (2014) and Galili and Bar (2001) concerning the intuitive physics of free fall and gravity.

After finding out the profile of conceptual change preservice elementary teachers using Direct Instruction, remedial teaching was conducted to change their conceptions. The participant conception profile and conceptual change level about Free Fall are shown in **Figure 4**.

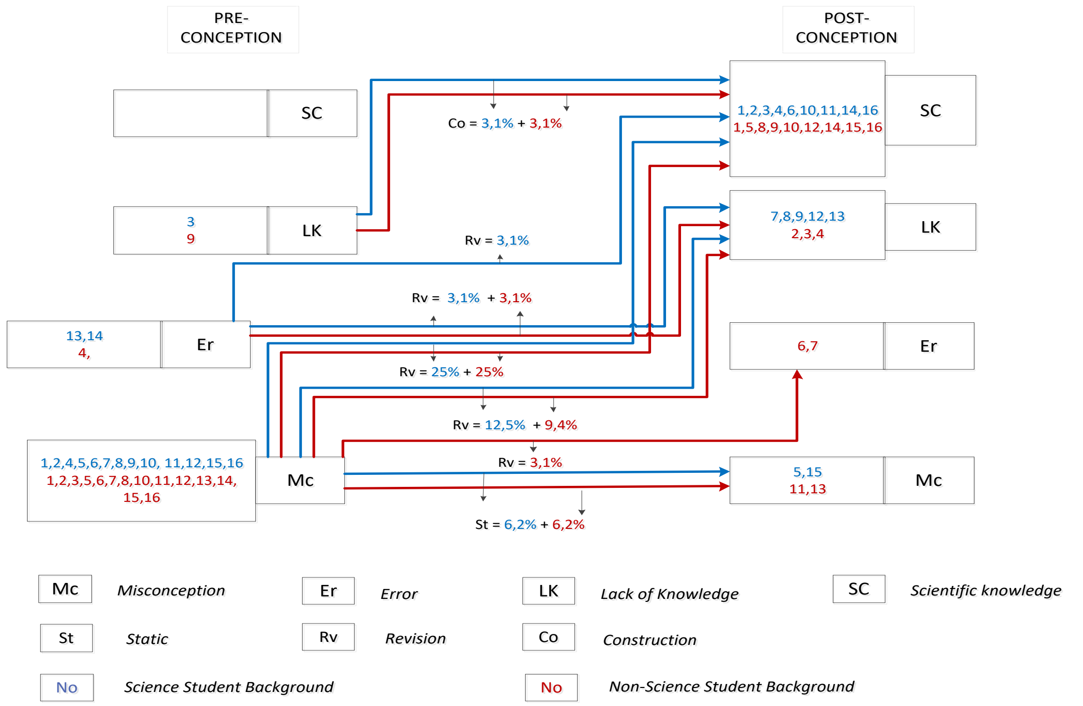

Figure 4. The Conception Profiles and *Conceptual Change* Levels of Preservice Elementary School Teachers' about Free Fall

Figure 4 have shown the participant conception profile and their conceptual change level about Free Fall. The data indicates that remedial teaching used RCCM-assisted Visual Multimedia led to conceptual change both classically and individually. Most of the elementary school prospective students, both those with a background in science and non-science high schools, have experienced revision of their initial conception. Even those who experienced revision from misconception to scientific knowledge, this was only half of the participants.

According to *accepted scientific theories*, as an example, on the motion of objects in free fall either in an open space or a vacuum, if objects with different mass are dropped simultaneously and from the same height, the objects will reach the bottom at relatively the same time, provided that air friction is ignored. The heavier objects will receive larger pressure than lighter objects. Heavier objects will get greater pressure than lighter objects. A 1 kg ball will get 10 N of weight force, while the 20 kg ball gets 200 N weight forces. However, since the acceleration was caused by a relatively same gravitational pressure equal to every object and the speed of falling of every object from the same height is also relatively equal, so all objects will arrive at the bottom at the same time (Allen, 2010: 123).

Heavier balls should have fallen faster due to a greater force, but since the ball has a larger mass, it needs a greater force to counter the inertia, which inhibits higher acceleration. The pressure of gravity and greater inertia will cancel out the effect so that each ball will experience the same acceleration and fall at the same speed, although having different mass (Allen, 2010: 123).

Learning Progression Map

L*earning progression* map of the preservice elementary teachers is in line with the development of the *conceptual change* that occurred during the learning. With the same assumptions, the hypothetical *learning progression map* is shown in **Figure 5**.

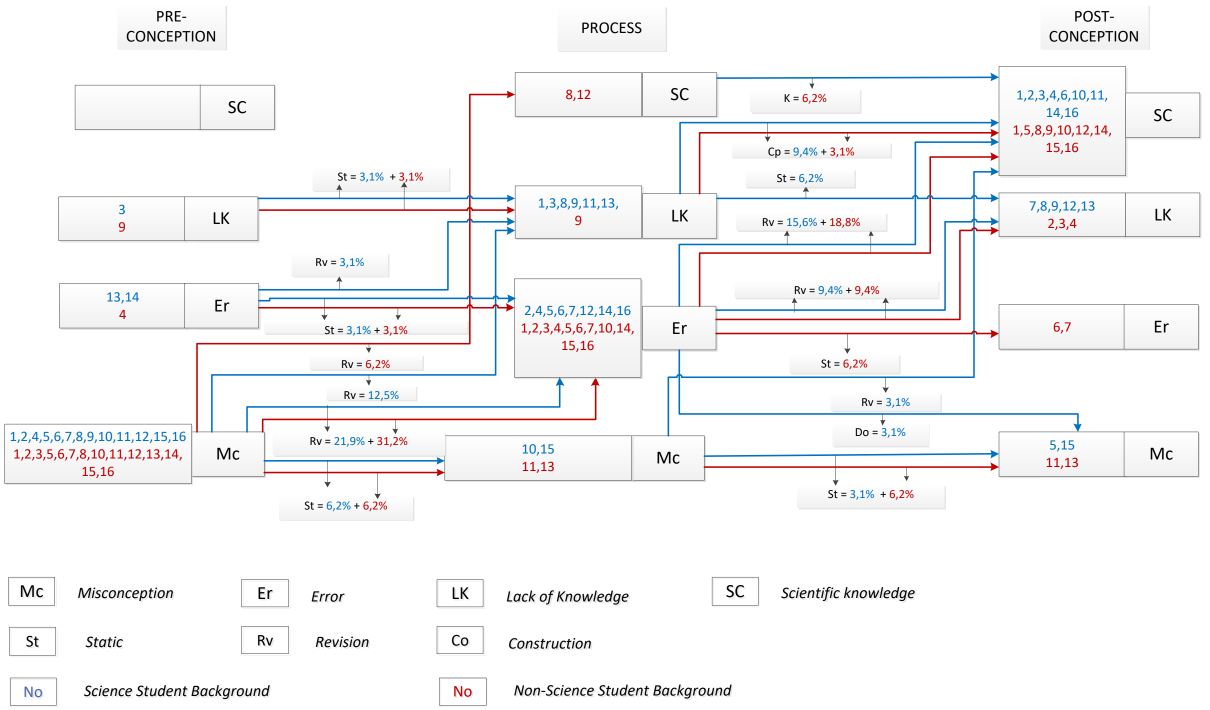

Figure 5. Hypothetical Learning Progression Map of Preservice Elementary Teachers on the Understanding of concept Essential Concepts

Figure 5 has shown the change in the conception of preservice elementary school teachers' about Free Fall. Most participants have a pre-conception that heavier objects will fall faster. After doing hands-on activities, most participants still have the same conception with the pre-conception, but with a better understanding that the speed of objects falling is influenced by gravity, especially those who have a background in the Science High School. After conducting guided discussion activities, most participants then believed that the weight of the object is not affected by the speed of the fall. More than half of the participants have confidence in this matter along with a scientific understanding that the speed of falling objects is influenced by gravity and altitude.

The results of this study indicate through discrepant event that supported RCCM visual multimedia, most of the preservice elementary school teachers', both those with a background in Science and Non-Science background have experience conceptual change gradually. The pre-conception of them about free fall motion is mostly in the misconception. During the process, there is a significant movement conception. The number of participants with non-science background has revised from a misconception to a higher error than those from science high school background. Whereas the number of them who are from science backgrounds who experience revision from misconception to lack of knowledge is greater than those from non-science. However, only a few elementary school prospective students were found with a background in non-science high school who had experienced revision from misconception to the scientific conception.

DISCUSSION

The profile of the pre-conception of most elementary school preservice teachers about Force and Motion have shown that they have misconceptions about concepts about Force and Motion. This misconception occurs both for students from science and non-science in high school backgrounds. This is consistent with the results of previous studies (such as Bani-Salameh, 2017; Anggoro, et al., 2017; Kiray et al., 2015; Halim, et al., 2014; Cepni & Sahin, 2012; Tasdere & Ercan, 2011; Darling, 2012 ; Allen, 2010; Unal, 2008; Unal & Costu, 2005; Yin, et al., 2008; She, 2002) which concluded that students, teachers and prospective teachers experienced misconceptions about Force and Motion. Misconception is not changed to scientific conception easily because it was formed from elementary school.

Misconception, error or lack of knowledge can occur because the teacher does not understand the concept and how to teach inappropriate or school-made misconceptions (Barke et al., 2009: 21, Burgoon, et al., 2010; Stein et al., 2008). Besides that, many teachers were not academically prepared to teach science in accordance with the accepted scientific theory (Halim, et al., 2014). So that students' understanding tends to rely on intuition and tactile experiences (Vicovaro, 2012, 2014; Galili & Bar, 1997). Research results (such as Anggoro, Widodo & Suhandi., 2017; Bani Salameh, 2017; Driver & Easley, 1978; Driver & Erickson, et al., 1983; Halim, et al., 2014; Ozsevgec, 2006; Tsai, 1998; Suppapittayaporn, et al., 2010; Wandersee, Mintzes, & Novak, 1994) conclude that misconception tends to be difficult to change. However, Limon (2001), Vosniadou (2008, 2014) and Vosniadou and Ionanides (1998: 1203) state that conceptual change in science learning takes place gradually through a series of activities carried out in a continuous and structured manner.

Results of the study indicate that, hypothetically, the occurring conceptual changes were not always gradual and follow tiered stages. Besides, the learning progressions showed that the use of discrepant event in cognitive conflict strategy is able to create a better conceptual change or deep conceptual change (Limon & Carretero, 1997; Drenth 2006; Martinson et al., 2005; Masnick & Klahr 2003; NGSS, 2013; Toth, 2016).

Discrepant events supported by multimedia-assisted learning have a positive impact on student learning outcomes in both cognitive aspects (Goldman, 2004; Lin, 2010; White, et al., 2000), psychomotor (Donkor, 2010), and affective domains (Choi & Johnson, 2005) . Thus, with multimedia assistance provides more meaningful results for students. The used multimedia can inspire students, attract their attention, and stimulate their motivation while communicating their conceptions. Shah & Khan (2015: 350) and Lee (2002: 513-514) found that the use of multimedia contributed positively to the development of critical and objective thinking skills. Visual multimedia can help students search for more interesting and clearer information about abstract concepts (de Sousa et al., 2017).

Through multimedia-based learning, it can encourage and enhance the ability of students to create and innovate (Malik & Agarwal, 2012: 468). Besides, multimedia-based learning is effective to produce more quality learning outcomes (Lee & Keckley, 2006). Akpinar, et al. (2014) argue that collaboration between multimedia use and teacher guidance makes students able to develop discussion skills scientifically and improve their learning outcomes. Jarosievitz (2011: 22; 2009: 383) explains that the skills to use multimedia can support cognitive abilities and skills of prospective teacher students. Deeper learning of students can occur when teachers use integrated media (Mayer, 2001: 44; Mayer, 2002: 62-67; Moreno, 2004: 102). Visual multimedia can make students solve problems through self-exploration, collaboration and active participation, through the integration of simulation media, modeling and media-rich study materials (such as the use of images, animation, video and audio) (de Souza et al., 2017).

Discreprant events were helped of simulations based on cognitive conflict theory turns out to increase meaningful conflict (Nilsson & Castro, 2013). Then, cognitive conflict strategies with the help of demonstration videos can be used to make students make resolutions that will lead to a higher understanding of concepts (Baddock & Bucat, 2008). This means that the combination of the effectiveness of anomaly phenomena along with visual multimedia can lead to a more meaningful learning process for students.

Thompson and Logue (2006) argue that through hands-on activities there are many scientific concepts that can be understood by students. Furthermore, discrepant events used hands-on activities, including concrete activities, are considered the best way to improve students' understanding of abstract concepts. These activities support the cognitive skills of students who do not develop in the expected time and they may not understand abstract concepts and theories using traditional approaches such as lectures (Inhelder & Piaget, 1958, 2013).

Hands-on activities helped students develop conceptual understanding, which can be done individually, in small groups, or even as one class (Thompson & Logue, 2006). These activities can present the most appropriate environment for students to gain learning experiences through different learning strategies. Through hands-on activities, students use different senses in science classes by touching, feeling, moving, observing, listening, kissing, and sometimes testing the material in a controlled manner. This helps them to move from the level of concrete thinking to a more complex level of thinking (Kahle & Damnjanovic, 1994; Case & Fraser, 1999; Jones et al., 2003; Bilgin, 2006). As an active learning technique, hands-on activities enable students to build scientific understanding in a pleasant learning environment (Anggoro, et al., 2017; Case & Fraser, 1999; Kahle & Damnjanovic, 1994). They can be actively involved in the process of building their own knowledge structure through information obtained in these activities. In fact, hands-on activities can increase the affective of students towards investigations, and make them have the opportunity to observe the relationship between natural phenomena and scientific facts (Jones, et al., 2003; Bilgin, 2006).

The students' misconceptions are experienced because to the accumulation of knowledge gained since elementary school to high school and are less likely to change (Arts, 2005; Suppapittayaporn, *et al.*, 2010; Halim *et al.*, 2014). This condition was caused by the learning process that the teachers commonly use, which is lectures on the laws and the historical concepts of force and motion, so it is only *rote learning* and not building meaningful learning (Rane, 2015). Besides, teachers are not trained to deal with the misconceptions (Halim *et al.*, 2014).

Learning models can affect students' cognitive conflict (Ab Rahim, *et al.*, 2015). This means that students receive discrepant event and then accommodate the knowledge they have before. In addition, students who are given learning using meaningful learning will react to a problem by asking themselves and by connecting and elaborating ideas (Donn, 1989). This contributes to successful cognitive involvement. Borghi *et al.* (2005) introduced the learning strategy called a teaching-learning sequence on free fall motion. This learning strategy integrates the activities of experiments and computer simulations to explain the concept of free fall motion. In addition, Vera and Rivera

(2011) reported a mainstream simple experiment that lighter objects fall faster than the heavier objects. Both learning activities aimed at improving students' *awareness* through explicit knowledge of free fall (Zago & Lacquaniti, 2005).

The validity of discrepant events affects the learner response rate (Chinn & Brewer, 1993; Limon & Carretero, 1997). The validity includes alternative theories that are reasonable and valid. Then, it is supported by the learning strategies that encourage learners to engage actively to construct an understanding of the learned concepts, through experiments, demonstrations, discussions, or visual representations (Chinn & Brewer, 2001)

The effectiveness of cognitive conflict strategies in learning procedures and understanding has been proven through the results of research conducted in various subjects (Dahlan & Rohayati, 2012; Baser, 2006). Cooperative learning using cognitive conflict strategies can actually improve critical and creative thinking in learning mathematics (Dahlan & Rohayati, 2012). In addition, cognitive conflict increases students' understanding of Physics concepts that are better than traditional learning (Baser, 2006). Learners are better able to analyze and integrate inconsistencies between discrepant events in Science and their conceptions by using this cognitive conflict strategy (Kang, Scharmann & Noh, 2004).

Learning with simulations based on cognitive conflict theory can actually increase meaningful conflict (Nilsson & Castro, 2013). Then, cognitive conflict strategies with the help of demonstration videos can be used for students to make resolutions that will lead to a higher understanding of concepts (Baddock & Bucat, 2008). This means that the combination of cognitive conflict strategies and visual multimedia can lead to a more meaningful learning process for students.

Research showed that traditional teaching-learning methods such as lectures or media such as textbooks are not effective in changing misconceptions (Champagne, *et al.*, 1983; Driver & Easley, 1978, Guzzetti, 2000; Thompson & Logue, 2006). There are several models, methods or alternative learning media such as concept maps, concrete activities, hands-on activities, conceptual change texts, computer-aided instruction, which have been used to achieve conceptual change and improve the conceptual understanding of students (Hewson, 1992)

When preservice elementary teachers learn physical concepts such as Force and Motion, through cognitive conflict strategy, they reconstruct knowledge or reconstruct their conceptions of the concept, comparing with their previous conception, through science process skills. The results of the study indicated that the prior conception of them is embedded relating to the misconceptions were formed from elementary school. So that the final conception about these concepts have shown a hybrid knowledge or synthetic conception when they combine the pre-conception with scientific concepts (Galili, 2001, Vosniadou, 2014, Vosniadou & Brewer, 1994).

In science learning, through finding misconceptions experienced by students, then following up with designing teaching models and strategies based on findings, the learning so developed will provide meaningful learning experiences (Chia, 1996). This step will allow students to recognize their misunderstandings, correct them, then consistently use the process of interpreting more complex phenomena and concepts of physics.

CONCLUSION

Understanding how to learn science and improve the quality of the learning process are crucial. Understanding how learners responded to scientific information that is contrary to the belief of preconception held, is the heart of knowledge acquisition in science. This shows the importance of preservice teachers understand the nature of science as whole. That understanding will become the foundation for the learners' cognitive development in understanding the real world.

The study results indicated that most preservice elementary school teachers had reached the level of scientific conception through RCCM-assisted visual multimedia that discrepant event as become important part of this model. This will build an understanding of science that is *in line* with the dynamic development of science and technology. The presentation of the discrepant event in the cognitive conflict learning strategy can eliminate the preservice elementary school teachers' misconceptions on essential concepts in science.

Conceptual change through RCCM assisted-Visual Multimedia become alternative remedial learning that does not merely improve the concept by memorizing or giving questions with lower levels of difficulty. The purpose of developing the model is to reconstruct or construct the conception so that preservice elementary school teachers understand and believe in scientific concepts, even with diverse high school backgrounds. Besides that, teachers need to be equipped with an understanding of the correct concepts coupled with training in the use of RCCM models assisted by Visual Multimedia. This is an alternative effort to change the conceptions of their students to get constructive and meaningful learning. Thus, an understanding of conceptual change, learning progression, representation, and the essence of science are important in preservice elementary teachers' education.

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