Elementary Student Conceptual Change About Free Fall Using Reflective Conceptual Change Model

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Abstract: Students and even teachers, particularly in elementary schools, continue to have misconceptions about free fall. When using traditional learning methods, it is difficult to change these misconceptions. The purpose of this article is to reconstruct elementary school students' conceptions using a reflective conceptual change model (RCCM) aided by visual multimedia. The research design is quasi-experimental. The participants in this study were grade 4 elementary school students, 20 of whom were female and 10 of whom were male. A four-tiered test and an observation sheet were used as research instruments. Using data analysis, the findings revealed that all students had a new perspective on free fall. Male students improved their conceptual revisions better than female students. There are 90% of male students experiencing a conceptual change from misconception to scientific conception, compared to 15% of female students. RCCM assisted by visual multimedia can improve students' conception to a higher level.

Keywords: Conceptual change; Reflective conceptual change model; Free fall; Elementary student

Introduction

Misconceptions about free fall persist among students and teachers, particularly in elementary school (Anggoro et al., 2019a, 2019b; S. Anggoro et al., 2017 Anggoro et al., 2020a; Lemmer, 2018; Millham & Isabelle, 2013; Potvin et al., 2020; Potvin & Cyr, 2017; Tuningsih et al., 2020). Misconceptions are difficult to change when using traditional methods of learning (Anggoro et al., 2017; Anggoro et al., 2020b; Bani-Salameh, 2017; Halim et al., 2019, 2020).

One reason for the difficulty in revising misconceptions is that teachers are less equipped with scientific concepts (content knowledge), how to engage students in learning (pedagogical content knowledge), and have not yet used technological content knowledge (Anggoro et al., 2019a; 2019b; Halim et al., 2019; Madden et al., 2016; Zainuddin et al., 2020). This has an impact on misconceptions that will occur in the future.

Cognitive conflict strategies are generally used in trying to solve misconceptions regarding various science concepts between many students, teachers, and preservice teachers. Cognitive conflict strategies, according to Hermita et al. and Nilsson & Castro, can be used to reconstruct teacher candidates' misconceptions about the concept of electricity (Hermita et al., 2018; Nilsson & Castro, 2013). Previous research (Allen & Kambouri-Danos, 2017; Anggoro et al., 2017; Anggoro et al., 2019b) also concludes that cognitive conflict strategies can reduce the level of misconceptions in physics, biology, and chemistry lectures.

Anggoro et al. created the Reflective Conceptual Change Model (RCCM) with the help of visual multimedia (Anggoro et al., 2019). This model was created based on a number of results studies (Aydeniz & Brown, 2010; Chinn & Brewer, 1993; Herrenkohl & Cornelius, 2013). RCCM employs a cognitive conflict strategy that begins with students losing their beliefs through conflicting learning experiences that allow them to replace misconceptions with scientific concepts (Anggoro et al., 2019; Bani-Salameh, 2017; Hadjiachilleos et al., 2013). Some previous research findings (Allen &

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Kambouri-Danos, 2017; Anggoro et al., 2017; Anggoro et al., 2019) also conclude that cognitive conflict strategies can be used to reduce conflict. This article purpose is to analyze the students' conception about freefall during learning process used this model.

According to constructivist theory, every child has an initial conception of the universe. , there is an active process of constructing knowledge during the learning process, resulting in a "change in learning conception" from the initial, often incorrect, conception to a scientific conception. So conceptual change is defined as the cognitive activity in learning (Anggoro et al., 2017, 2019; Treagust et al., 2017; Duit et al., 2013).

Posner et al. (1982) were the first to discover a conceptual change model. Many researchers then developed and expanded on their ideas (Anggoro, et al., 2019; Aydeniz & Brown, 2010; Baser, 2006; Chinn & Brewer, 1993; Hadjiachilleos et al., 2013a, 2013b; Kural & Kocakulah, 2016; Niaz and Maza, 2012).

Several researchers have created learning strategies that can be used to achieve conceptual shifts. Cognitive conflict (Allen & Kambouri-Danos, 2016, 2017; Anggoro et al., 2019; Dahlan et al., 2012; Duncan et al., 2016, 2017; Hermita et al., 2020; Kambouri-Danos et al., 2019; Kang et al., 2010; Labobar et al., 2017; G. Lee & Byun, 2012; Nilsson.

Cognitive conflict begins with students dissolving their conceptions through conflicting learning experiences that allow them to replace misconceptions with scientific conceptions (Anggoro et al., 2017, 2019, 2020; Hadjiachilleos et al., 2013; Hermita et al., 2020; Kang et al., 2010; Lee & Byun, 2012; Tuningsih et al., 2020). This strategy has been shown to be effective in dispelling myths (Anggoro et al., 2017, 2019; Hermita et al., 2020; Suhandi et al., 2020; Tuningsih et al., 2020).

Cognitive conflict strategies have been widely used in reconstructing students', teachers', and prospective teachers' misconceptions about various science concepts. According to Hermita et al. (2018) and Nilsson & Castro (2013), cognitive conflict strategies can reconstruct teacher candidates' misconceptions about electricity (Hermita et al., 2018; Nilsson & Castro, 2013).

Several previous studies concluded that cognitive conflict strategies can reduce the level of misconceptions of several concepts in physics, chemistry, and biology (A'yun et al., 2017; Allen & Kambouri-Danos, 2017; Anggoro et al., 2017, 2019; Atasoy et al., 2011; Atasoy & Ergin, 2017; Hermita et al., 2020; Labobar et al., Madu and Orji (2015), Rahim et al., 2015a, and Singh (2014) concluded that cognitive conflict strategies can reduce the level of misconceptions in physics, chemistry, and biology.

Furthermore, Learning Progressions provides teachers with supporting information on how students understand science core ideas as well as learning strategies that support student learning progress. In

The Reflective Conceptual Change Model (RCCM) was created by Anggoro et al. (2019). This model was created based on the findings of research conducted by Chinn and Brewer (1993), Aydenis & Brown (2010, 2017), Hadjiachilleos et al. (2013), Lee and Yi (2013), Lee (2014), and Lee et al (2003). RCCM employs a cognitive conflict strategy that begins with students losing beliefs through conflicting learning experiences that allow them to replace misconceptions with scientific ones (Anggoro, et al., 2019; Hadjiachilleos, Valanides, et al., 2013; Kang et al., 2010; Kang et al., 2004, 2005; Tuningsih et al., 2020).

Several researchers' conceptual change models (such as Anggoro et al., 2019b; Aydeniz & Brown, 2010; Hadjiachilleos, Valanides, et al., 2013; Hermita et al., 2020) share several similarities. Each model employs discrepant events (developed by Anggoro et al., 2019b and Nussbaum & Novick, 1982) as well as terminology such as anomalous data (Lee & Byun, 2012; Muhali et al., 2019), anomalous situations (Lee & Byun, 2012; Kim et al. , 2006; Lee et al., 2003; Hadjiachilleos et al., 2013). Furthermore, several researchers adapted and added to Chinn and Brewer's (1983) level of conceptual change (such as Hadjiachilleos et al., 2013; Kang et al., 2010; Lee & Byun, 2012; Oh et al., 2017).

Conceptual change is a continuous process that corresponds to a more sophisticated understanding of the nature of science. The evolution of a concept or a conceptual shift is an essential part of the student learning process. Learning progressions are used to describe students' progress from preconception to scientific conception (Allen & Kambouri-Danos, 2017; Anggoro et al., 2019a; Opitz et al., 2019; Wang et al., 2015a, 2015b, 2017).

Learning progressions produce a map of changes in students' cognition as they learn a concept (Steedle & Shavelson, 2009; Yin et al., 2013, 2014). Learning Progressions focuses on the ideas of students. Learning progressions are progressions of increasingly sophisticated ways of thinking and reasoning that students use to comprehend the real world. As a result, learning progressions will be more effective in guiding meaningful science teaching and learning in the classroom (Fulmer et al., 2014; Jin et al., 2019; Jin & Anderson, 2012; Lee & Yi, 2013; Liu, 2013). Although Learning Progressions are concerned with the development of individual student learning abilities, they can also be used to describe how students progress from preconception to scientific conception in general (Allen & Kambouri-Danos, 2017; Hadenfeldt et al., 2014; Liu, 2013; Todd & Romine, 2013; Yao et al., 2017).

general, learning progressions describe how students' understanding develops (Alonzo, 2018b, 2018a, 2018a; Gao et al., 2020; Gotwals, 2018; Gotwals & Birmingham, 2016; Gotwals & Songer, 2013; Mohan, 2018). The

Learning Progressions model aims to engage students in reflective practice through meaningful scientific activities (elik, 2020; Koenig et al., 2012; Wang et al., 2015, 2017; Xu et al., 2020; Yao et al., 2017).

Research on Learning Progressions has been widely conducted in science learning such as biology (Duncan et al., 2016; Furtak, Bakeman, et al., 2018; Hokayem & Gotwals, 2016; Jin et al., 2019; Mohan, 2018; Mohan et al., 2012; Xu et al., 2020), physics (Covitt et al., 2018; Gunckel et al., 2012; (Alonzo & Elby, 2019; Carroll et al., 2019; Cunningham, 2011; King, 2010). Science practices have also been the subject of Learning Progressions research (Berland & McNeill, 2010; Lederman et al., 2014; Xu et al., 2020). Meanwhile, some researcher used Learning Progressions as an assessment tool (Jin et al., 2017, 2019; Plummer & Maynard, 2014; Stevens et al., 2013; Wang et al., 2015).

Method

The research method chosen will be quasi-experimental. The participants in this study were 30 forth grade students, included 20 girls and the rest is boys, from a private elementary school in Banyumas Regency. Conception tests and student worksheets are among the tools employed. and a sheet of validation The conception test consists of two questions about Free Fall and Vacuum Free Fall. The worksheets that are created are also tailored to the learning plan.

A description of the conceptual change and learning progression that occurred during the learning process will be obtained based on the answers given by the students when filling out the worksheets and the conception test. Based on the feedback given to students when completing worksheets and tests, there will be evidence of conceptual change and learning progression throughout the learning process.

Conception categories are used to determine the differences in the answers given at the beginning, middle, and end of the process, which are classified based on the level of student answers. According to Tables 1 and 2, the category of conception and level of conceptual change adapt the response model to divergent events developed by Kaltakci-Gurel & Didis (2007) and Kaltakci-Gurel et al. (2017). In addition, the model conceptual change was hypothesized using the Visio 2010 software.

Students make decisions about conceptual status and conceptual changes. As a result, theoretically, their conceptual status and conceptual changes will be influenced by the initial conception and the accompanying learning process, resulting in their final conception. Furthermore, the pattern of changes in students' perceptions can become more scientific, permanent, or even worse than before. Table 2 depicts the pattern of changes in conception.

Table 1. Conception Categories based on participant answered

Tier 1	Tier 2	Tier 3	Tier 4	Category
Correct	Sure	Correct	Scientific	Scientific conception
Correct	Sure	Correct	Unscientific	
Correct	Unsure	Correct	Scientific	
Correct	Unsure	Correct	Unscientific	Lack of knowledge
Correct	Sure	Incorrect	Scientific	
Correct	Sure	Incorrect	Unscientific	
Correct	Unsure	Incorrect	Scientific	
Correct	Unsure	Incorrect	Unscientific	
Incorrect	Sure	Correct	Scientific	Error
Incorrect	Sure	Correct	Unscientific	Lack of
Incorrect	Unsure	Correct	Scientific	knowledge
Incorrect	Unsure	Correct	Unscientific	
Incorrect	Sure	Incorrect	Scientific	Error
Incorrect	Sure	Incorrect	Unscientific	Misconception
Incorrect	Unsure	Incorrect	Scientific	Lack of
Incorrect	Unsure	Incorrect	Unscientific	knowledge

Table 2. Conceptual Change Levels based on Initial and Final Conceptual Changes

Initial Conception	Final Conception	Category
Scientific conception	Scientific conception	Knows from the beginning
Scientific conception	Lack of Knowledge	
Scientific conception	Error	Disorientation
Scientific conception	Misconception	
Lack of Knowledge	Scientific conception	Complementation
Lack of Knowledge	Lack of Knowledge	Static
Lack of Knowledge	Error	Disorientation
Lack of Knowledge	Misconception	
Error	Scientific conception	Revision
Error	Lack of Knowledge	
Error	Error	Static
Error	Misconception	Disorientation
Misconception	Scientific conception	Revision
Misconception	Lack of Knowledge	
Misconception	Error	
Misconception	Misconception	Static

Result and Discussion

In the pre-learning, students reveal the predictions/preconceptions that students have regarding the concept of free-falling objects through revealing puzzle questions. Then, they doing proof to solve the phenomenon or the results of the experiment, comparing the "*genuineness*" of the problem with their preconception, and Develop and evaluate scientific understanding of the concept of free-falling objects. The next step is students build a stronger understanding using different discrepant events. Lastly, teacher

mapping the *learning progression* of students' *conceptual change* about the concept of free-falling objects.
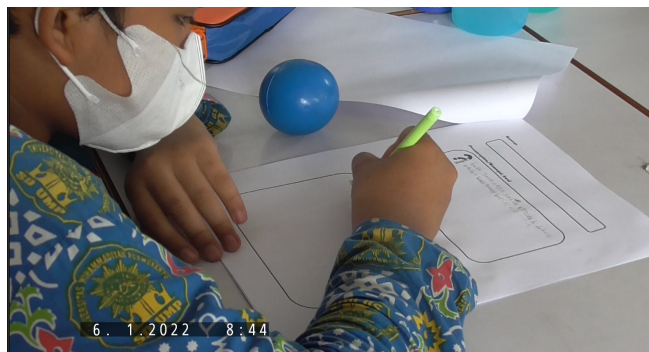

Prepare

Predict

Observe

Explain

The motion of free falling objects is a fundamental physics concept that has been studied by Aristotle, Galileo, and others up to the time of this research (Anggoro et al., 2017; S. Anggoro et al., 2019; Franco, 2011; Halim et al., 2020; Vicovaro, 2014)[1-3][10][22-23]. Figure 4 shows the initial conception profile, process, and end participants for the concept of motion of a free falling object.
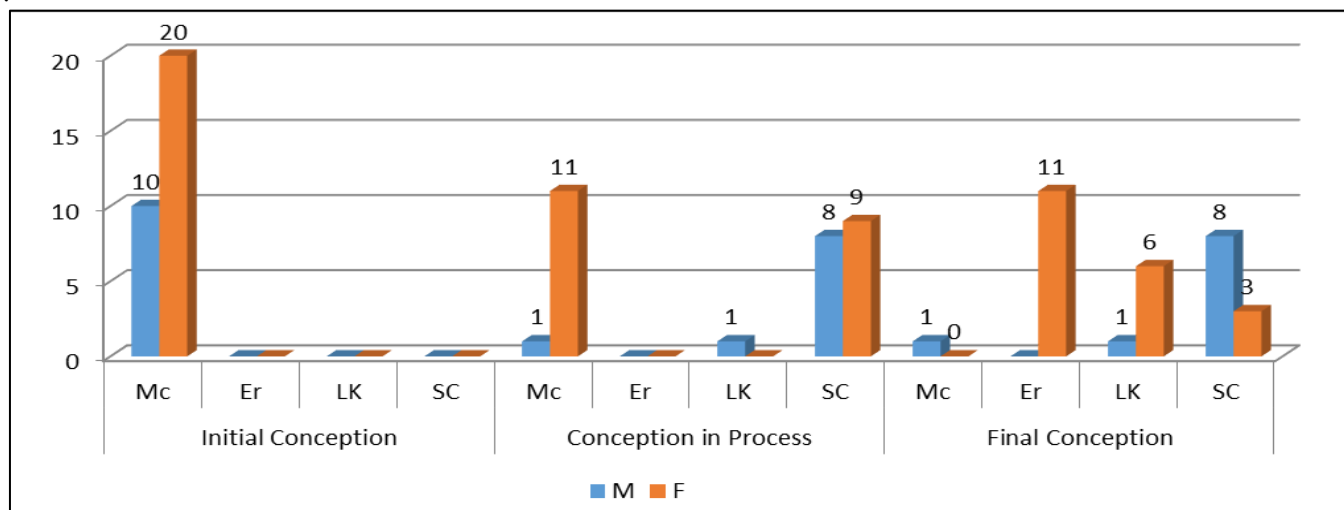

Figure 1. The Conception Profile of Forth Graders about Free Fall Objects

Information :
Mc : Misconception   Er : Error
LK : Lack of Knowledge   SC: Scientific Conception
M: Male   F: Female

Figure 1 describes a profile of participants' perceptions of free-falling objects. In the early stages of learning, all participants believed that the mass or weight of a falling object affected its speed. This shows

that elementary school students are confident in their understanding of the incorrect concept or misconceptions concerning the principle. Several previous studies (Anggoro et al., 2020; Bani-Salameh, 2017; Franco, 2011; Vicovaro, 2014, 2018) support the findings of this study.

Misconceptions or errors can occur as a result of the teacher's lack of understanding of concepts and inappropriate teaching methods, as well as school-created misconceptions (Barke et al., 2019.; Belachew et al., 2021; Burgoon et al., 2011). Furthermore, many teachers lack the necessary training to Science should be taught in accordance with accepted scientific theory (Vicovaro, 2012). As a matter of fact, students' understanding is dominantly based on perception and tactile experiences (Franco, 2011; Vicovaro, 2012, 2018).

Based on the participants' predictions about four different masses of plastic balls (each ball is filled with one, two, three, or four marbles) when dropped from the same height, all students, both boys and girls, had misconceptions. According to Rohrer (2002) and Vicovaro (2014), the mass-speed belief is a common misconception about the motion of free-falling objects. Following the completion of the test, all of the balls are dropped, resulting in a change in conception. According to Table 3, 80 percent of students (boys) and 45 percent of students (girls) understand that the entire ball will fall almost simultaneously. As a result, the student's perception of motion has shifted from one of misconception to one of scientific understanding.

To determine the dependability or consistency of students' understanding of draft motion thing fall down free, students were asked about their conception of motion thing fall down free in vacuumed. Based on the response, all students predict that heavier objects (bowling ball) will fall down faster than lighter objects (feather birds). On the following activity, students view YouTube impressions (Brian Cox visits the world's biggest vacuum | Human Universe - BBC) about NASA test drop things in space empty. After seeing impressions that, 90% of boys and 15% of girls state that second different things, both heavier and lighter things will fall down simultaneously. However, there are 55% of students who believe that lighter would fall down more quickly.

Figure 1 describes a participant's profile regarding a motion thing falling down free. According to the data, strategy conflict cognitively causes good conceptual change by classic as well as individually. Part of large students have experience revising their conceptions from the start. Even those who have undergone revision from misconception to scientific knowledge account for half of all elementary school teachers. Then, Figure 2 shows the conceptual change participant's description of Free Fall.
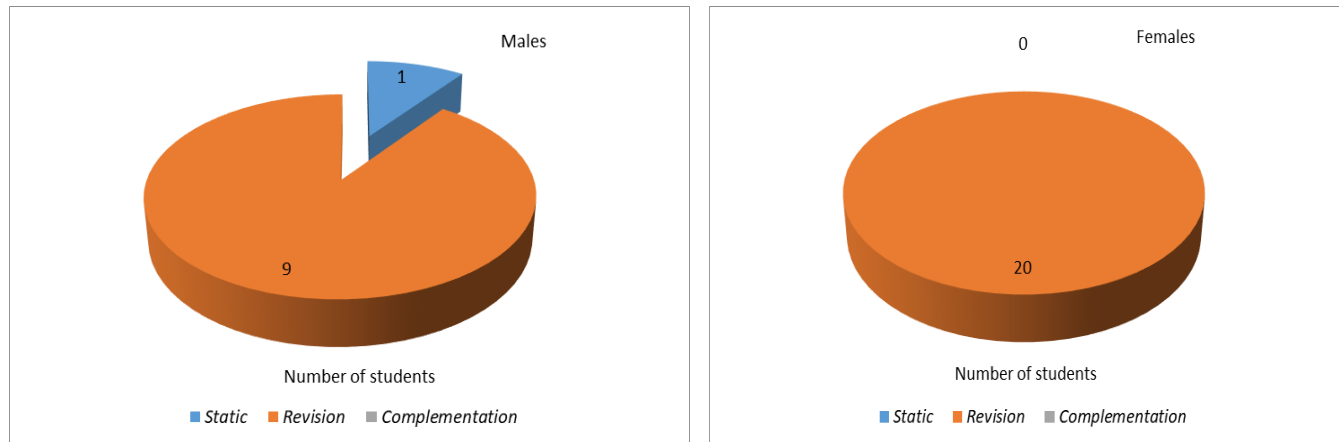

Figure 2. Profile of Student Conception Reconstruction about Motion of Free Falling Objects

RCCM, with the assistance of e-multimedia, was able to increase conceptual change in students regarding the concept of Motion of Free Falling Objects in a more scientific manner. The majority of the students, both boys and girls, during the lesson, the girls experienced revision after experimenting with different weighted balls being dropped at the same height and time.

When compared to student females, student men tend to experience more conceptual change tall. Almost the entire student body undergoes conceptual change as a result of a misconception becoming a scientific conception. However, 55% of female students experience reconstruction as a result of a mistaken belief. On the second observation test, they conclude that more things light will fall down more first in the empty room. Only 15% of female students have a scientific perspective on the end of learning.
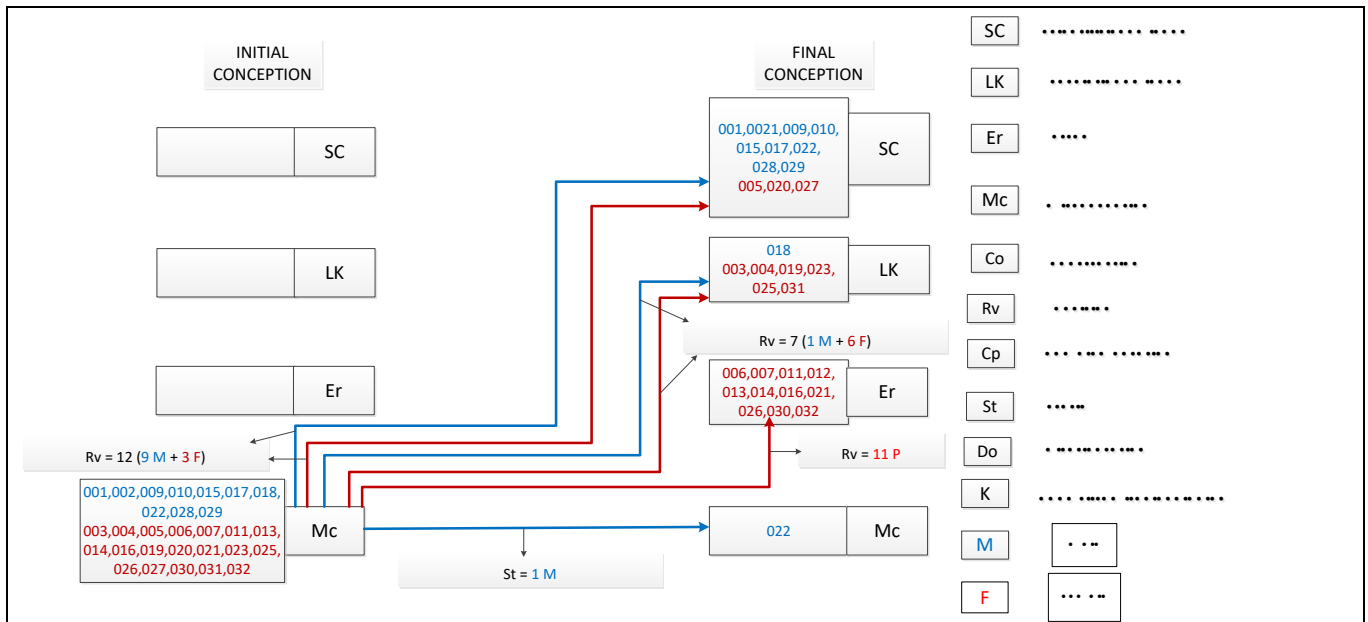
Figure 3. Profile of Student Conceptual Change about Motion of Free Falling Objects

Although some participants correctly understand the concept of free falling objects, the concept remains intuitive. This is supported by the answers of some participants, especially student women, who understand that lighter objects will fall down faster than heavier objects. This suggests that misconceptions are difficult to convert into scientific concepts in a short period of time.

The RCCM is aided by e- Multimedia. Visual is effective in reconstructing students about Free Fall. This model includes several components that contribute to the effectiveness of the reconstruction of student conceptions. These components are as follows: (1) discrepant events; (2) conflict-resolution-reiterate stages; (3) hands-on activities; (4) predict-discuss-observe-discuss-explain (PDODE); and (5) simulation videos.

Discrepant event presentation is the first step in the process of conceptual change in cognitive conflict learning strategies (Hadjiachilleos et al., 2013; Toplis, 2007; Vosniadou, 2014). Scientists and engineers use discrepant event to develop new interpretations, which leads to new conceptualizations and, finally, deeper conceptual changes. Presenting this events is also an important step in the conceptual change process (Allen & Kambouri-Danos, 2017; Halim et al., 2019; Herrenkohl & Cornelius, 2013; Oh et al., 2017).

According to Yin et al. (2008), teachers should: (a) identify students' current initial conceptions of the topics to be taught; (b) guide students to realize the limitations of these misconceptions; and (c) guide students to recognize the universality of scientific conceptions in order to facilitate the reconstruction of students' conceptions towards a scientific understanding of natural phenomena or scientific concepts.

The Visual Multimedia-assisted RCCM model is an adaptation of Reflective Conceptual Change, which was adapted from (Aydeniz & Brown, 2010; Chinn & Brewer, 1993). This model employs a cognitive conflict strategy, which begins with the process of dissolving beliefs through the use of contradicting learning experiences or discrepant events that allow students to replace misconceptions with scientific concepts (Bulunuz, 2015; Fischer et al., 2018; Herrenkohl & Cornelius, 2013).Furthermore, during the conflict-resolution-reiterate stage, the majority of the participants experienced a reconstruction of conception toward.

Students' observations frequently contradict their predictions due to misconceptions. Visual Multimedia-assisted RCCM, which in its early stages employs PDODE, assists students in realizing the limitations of their misconceptions and accepting scientific concepts scientifically (Anggoro et al., 2019b; Herrenkohl & Cornelius, 2013; Oh et al., 2017). The goal of PDODE activities is to provide students with sensory experiences on which they can base scientific concepts. In addition, through *the conflict-resolution-reiterate stage*, most of the participants experienced a reconstruction of conception towards a *scientific conception* (Allen & Kambouri-Danos, 2017; Aydeniz & Brown, 2010; Fischer et al., 2018).

Conclusion

RCCM, with the assistance of e-multimedia, was able to increase conceptual change in students regarding the concept of Free Fall in a more scientific manner. The majority of the students, both boys and girls, have revised their conception after experimenting with different weighted balls being dropped at the same

height and time. The RCCM is aided by e–Multimedia Visual is effective in reconstructing students about Free Fall. This model includes several components that contribute to the effectiveness of the reconstruction of student conceptions. These components are as follows: discrepant events, conflict-resolution-reiterate stages, hands-on activities, predict-discuss-observe-discuss-explain (PDODE), and simulation videos. Based on the results, further research is needed, regarding the effectiveness of this model on students' conceptual change in abstract science concepts such as electricity and magnetism.

Acknowledgements

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