Pre-service Elementary Teachers Understanding on Force and Motion

By Subuh Anggoro

Pre-service Elementary Teachers Understanding on Force and Motion

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Abstract. The research is done to investigate the understanding on the subtopic of Force and Motion that exists among the pre-services elementary teachers. The participants were 71 Elementary Teachers Study Program students in 6th and 77 one in 2nd semester at private university. Research instrument consisted of background information of respondents, belief of preconception and 8 questions that relates to Force and Motion with four alternative answers and their explained. Descriptive statistics such as percentage and bar chart were used for analyzing the data collected. Research findings have shown many participants have some misunderstand or misconception conception especially in free fall object, rest object, buoyant force and gravitation. This research recommends learning progression pre-services teachers to be exposed with conflict cognitive strategy for science conceptual change.

1. Introduction

Most of primary school student and teacher have no science concepts understood sufficiently [1,2]. Eventhough both of them have same concept misunderstood or naive conception [3,4]. This is because many primary school teachers are ill-equipped to teach conceptual science since they often hold views of science concepts that are in conflict with accepted scientific theory [1].

Most students begin to learn science contents with preconceptions that differ from scientific conceptions [5,6,7,8]. Initial ideas held by students are very difficult to change by teacher despite being presented with scientific concepts [9-14]. Teachers should identify students' understand before conducting formal teaching so that their misunderstand or misconception can be changed to scientific concept after the formal teaching and learning process [1].

To build an effective model of teaching and learning for teaching science it should begin by exploring or identifying difficulties and misunderstanding faced by students [15]. The objectives of this study is to identify the pre-service elementary understanding on force and motion.

2. Methods

2.1. Participants

One hundred dan forty eight pre-service elementary teachers at Universitas Muhammadiyah Purwokerto, seventy one from sixth semester, dan seventy seven second semester, participated in the study. One hundred and twenty five students (sixty from the sixth semester, and sixty five from second semester) were female, and the rest were male (eleven from sixth semester, and twelve from second semester. One hundred and sixteen student had general high school background (fifty seven from the sixth semester, and fifty nine from second semester), twenty nine from vocational high school (eighteen from the sixth semester, and eleven from second semester) and the rest passed Islamic religion school (all from second semester).

2.2. Research procedures

Multiple choice questions have been written based on the concept boundaries and in accordance with the extensive related literature on Force and Motion subtopic such as forces, gravity, free fall, and buoyant, to identify pre-service elementary teachers' conceptions understanding (can be seen on Table 1). Alternative conceptions or misunderstand or misconceptions were identified according to pre-service elementary teachers' answer and their reason. Pre-service elementary teachers completed the test as individuals and they were not required to write their names to assure anonymity. The survey administration lasted approximately 20–25 min. Parallel to coding and computations used, scale statistics were conducted to determine if the items functioned properly.

Table 1. Distributions of items according to subjects on Force and Motion diagnostic test

Subject	Items
Gravity	Q8
Free fall	Q1, Q2
Rest object	Q3, Q4, Q5
Buoyant	Q6, Q7

3. Result and Discussion

Descriptive statistics were conducted to analyze the pre-service elementary teachers' preconceptions, their answered and explained. These descriptive results can be interpreted as many preservice elementary teachers' understand have misunderstand even misconception on Force and Motion concept.

3.1. Free fall object

To explore the understand among the participants, the percentages of the students who misunderstood or misconcept and their answer on free fall object are reported in Figure 1. This figure indicates that most pre-service elementary teachers have misconceptions on free fall. Students believe that a heavier weight causes a greater acceleration in free fall (i.e., heavier objects fall faster) or that gravity varies significantly over a few meters [16-19]. The heavier objects will be pulled by gravity with a greater force than the lighter ones. However, the accelerations caused bythese gravitational pulls will be exactly the same for each object and their speed of falling will be equal at a given height, so they will all hit the ground simultaneously [19].

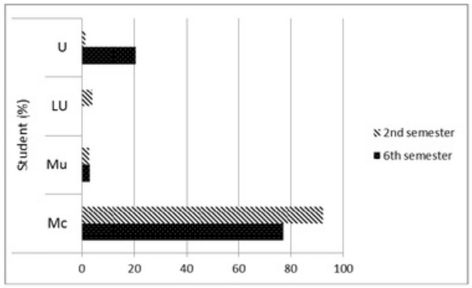

Figure 1. Pre-service elementary teacher preconception on free fall

Pre-service elementary teachers have some reasons that made their misunderstand or misconcepton on free fall. Most of them taught that heavy objects fall at a greater speed than light objects. Otherwise someone argued that light objects fall at a greater speed than heavy objects The object fall speed affected their size, mass or weight. Thus object weight affected gravitation.

There were some misunderstading even misconception on object fall in vacuum tube. Many of them thought objects drift caused no air pressure and no gravitation. They argued that object fall affected earth gravitation. Besides, without it all object would drifted. Some students have consistent misconception which anywhere heavy objects fall at a greater speed than light objects, even outer space. Some students which have correct answered gave some reason. Anyone thought that object fall affected gravitation and all object hit a ground simultaneously. The other argued object drift affected no air pressure and gravitation.

3.2. Rest object

To explore the understand among the participants, the percentages of the students who misunderstand or misconcept on rest object are reported at Figure 2. This is indicates that more half sixth semester preservice elementary teachers have misunderstand or misconceptions on rest object, thus were only quarter in second semester. Kruger and Palacio investigated British primary school teachers' understanding of the concept of force [20]. Results of the study revealed that many teachers were uncertain about what could be considered a force. Many teachers could not recognize that a table exerts an upward force on a body placed on it. More than half of the teachers were not aware that weight is gravitational force acting on bodies. Finding resultant force via vector addition was something new for those teachers.

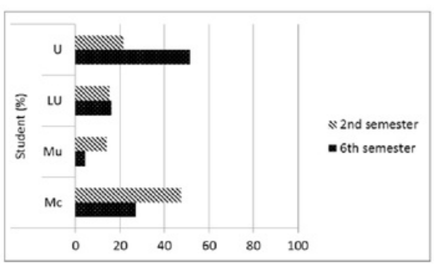

Figure 2. Pre-service elementary teacher preconception on rest object

Weight is a widely known force that with a little prompting many pupils would be able to name and correctly draw. However, some may correctly understand that a balanced system, and so add another arrow that shows an equal and opposite reaction force. Allen explained that the table is pushing up on the book in reaction to the book's weight, which balances everything out so there is no up/down movement [21].

Participants have some reasons that made their misunderstand even misconcepton on rest object. Most of them believed that there was no force. Someone argued that book have mass and/or weight. It has been affected gravitation and weight force. One student argued there barried the table, even gravitation received the situation and make weight force. Others thought object received pressure forced.

3.3. *Buoyant force*

To explore the understand among the participants, the percentages of the students who misunderstand or misconcept on buoyant force are reported in Figure 3. This is shows that most sixth semester preservice elementary teachers and half second semester have misunderstand even misconceptions on buoyant force. That is, the majority of student first think of large bodies and deep water as the spatial background of the situation of something floating and sinking [24]. Understanding properties of matter is of great importance, as these are considered foundational in science. One of the properties relevant to the substances bodies are made of is buoyancy [25]. Everyday observations of big objects floating and small objects sinking raise questions in their minds to which they provide answers and explanations directed by their intuitive naive beliefs and perceptual experiences [26]. A study by Kallery examined the impact of the teaching strategy employed on the growth of children's understanding of floating and sinking [27].

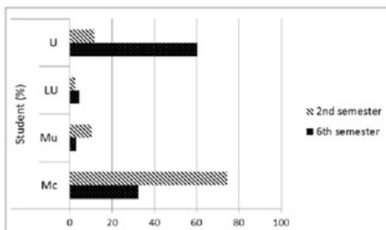

Figure 3. Pre-service elementary teacher preconception on buoyant force

Piaget found that children aged four to six may regard floating as a conscious or moral necessity (it is the right thing to do) or explain it in terms of cleverness – the 'boat is cleverer than the stone' [28]. Piaget and Inhalder reported that young children's explanations often focus on a single dimension and relate an object's floating or sinking either to its size or to its weight: heavy bodies sink while light bodies float, small bodies float while big ones sink and vice versa [29].

3.4. *Gravitation*

To explore the understanding among the participants, the percentages of the students preconception and their answered on buoyant force are reported in Figure 4. This result shows that most second semester preservice elementary teachers and more forty percent sixth semester have misunderstand even misconceptions on gravitation. It has long been known that students have difficulty with concepts that involve motions in space, reference points from Earth, and why objects appear to move as they do in the sky [30]. Since the weight of an object is the force it experiences due to gravity, weight can change depending on where the object is; on the other hand, its mass can never change without changing the object itself in some way [31].

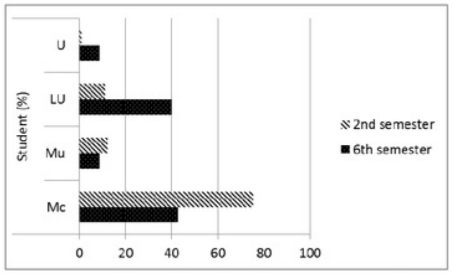

Figure 4. Pre-service elementary teacher preconception on gravitation

There are clear that most of the students surveyed response could not succeed in explaining why it happen. In other words, correct or incorrect with a statement does not provide evidence that a student understands a concept [30]. As a rule, incorrect on the inventory are more informative than correct choices [32]. The commonsense alternatives to the Newtonian concepts are commonly labeled as *misconceptions* [33]. These commonsense beliefs should be regarded as reasonable hypotheses grounded in everyday experience [33].

Many primary school teachers are ill-equipped to teach conceptual science since they often hold views of science concepts that are in conflict with accepted scientific theory [34,35]. Osborne and Freyberg have pointed out 'the doubtful value of teaching complex ideas based on faulty foundations' and 'the importance of the teacher's understanding of those ideas' [36]. It is also unfortunate that many of our elementary teachers are not required to take a sufficient number of credits in the sciences (unless they are in a science concentration) yet are still expected to teach science [30].

The process of bringing students' misconceptions to scientific accuracy is a long and arduous process that requires breaking down old understandings and building new conceptual understandings through processes that include "*uncovering student ideas*" and building a conceptual bridge from where students are to where they need to be [37-39]. Kelley and Sneider suggestsed that this process requires assessment probes to move students forward in their understandings [39].

Young children's processes of conceptual change, which occur in an instructional context and in the environment in which a cognitive conflict can be established, happen mostly in social interaction with other peers and the teacher. The conditions that facilitate orhinder the cognitive conflict, or in some other ways affect the conceptual reorganization, can be either internal or collaborative factors, which are continuously involved in the process of reorganization of everyday experiences [40].

Cognitive conflict can be defined as the imbalance created when newly acquired knowledge contradicts existing knowledge [41]. In terms of Piaget assimilation-disequilibrium-accommodation theory, cognitive conflict—i.e., difficulty in assimilating new (conflicting) knowledge into existing cognitive schemas—creates an unpleasant state of disequilibrium; the need to resolve this disequilibrium prompts the learner to accommodate the new knowledge, either by altering existing schemas or by developing new ones [42]. While Piaget developed his ideas to explain normal cognitive development in early childhood, cognitive conflict has been employed deliberately as a teaching tool for almost three decades, and specifically as a means of promoting conceptual change in mathematics and science education [43-45]. Conflict resolution is a crucial stage in the cognitive conflict process, without which new knowledge cannot be acquired. Chinn and Brewer said,

''When teachers attempt to use anomalous data to foster conceptual change, they may fail because students have several different ways to respond to the data other than theory change. A teacher could use the framework of alternative responses to try to anticipate how students might react to anomalous data'' [46]

Since 1990's, cognitive conflict based instructions have been extensively used in science education. Several studies concluded that that cognitive conflict has an important/positive effect on conceptual change [47,48]. Lee et. al. are insisting the need for cognitive conflict in order to conceptual change takes place[47]. Pintrich et. al. suggested that motivational constructs should be the potential mediators of the conceptual change process [49]. Sinatra and Pitrich and Anggoro et. al. also argued that conceptual change in science learning depends on not only cognitive factors such as the recognition of conflict, but also affective, metacognitive, and/or motivational factors[50,51].

To produce conceptual change, collaborative discussion that encourages thestudent to synthesize their views and draw relationships of causes and effects, compare and summarize is seen as important [52]. Thus for the children's conceptual change process the discussions held with teacher seemed to be the most significant. The causes for the flotation and different properties ofthe testing objects were reasoned about several times during instruction in collaborative discussion between the children and teacher, but only a few times in peer interaction..

Reasoning and its progression in elementary school students, that is to say, the extent to which elementary school students understand on Force and Motion as complex systems and whether their understanding changes as they progress to upper grades, have yet to be elucidated fully [53]. Lehrer and Schauble believed that students exhibit variation in their reasoning and so identifying students to strictly one level is not very common [54]. Alonzo and Steedle found that students' ideas about force and motion do not always belong to the same level for assessment questions that targeted the same concept in different contexts [55]. If this is true, the idea of defining learning progression as having clear-cut levels may be problematic. Gotwals and Songer found that the same students can demonstrate different levels of reasoning depending on specific questions [56].

4. Conclusions

According to this study, analysis of the student's understanding on Force and Motion is important in terms of developing teaching and supporting the student's knowledge construction. However, the process of conceptual change seems to be varying and context dependent. If student become familiar with the aspects of the phenomena as early as possible, the cognitive conflicts strategy in the instructional can becoming produce new ways to their conceptual change.

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