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Analysis the Conceptual Understanding Level and Understanding Model of Pre-Service Physics Teacher

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Abstract: Understanding in physics concept is needed to solve the problem in life. the aim of this research was to analyze the students' level of conceptual understanding level and students' model of understanding. It will help educators in selecting the suitable teaching approaches and strategies to gain conceptual understanding. This research design used a quantitative-descriptive model. The design aims to describe the conceptual understanding level of pre service teacher on Newton's Laws concept. The subjects were 40 students of Physics Education Department UNSAM who credited Fundamental of Physics course. Analysis conceptual understanding level and understanding model of pre-service physics teacher used instrument test which developed by Saglam. This research show that the students' level of understanding (pre-service physics teacher, UNSAM) was vary about Newton's law concepts but show the insignificant numbers among levels. Generally, students' achievement has no fallen progressively. It explains, students reach different success in the questions about conceptual understanding. While students' understanding models, they most appear in theoretical model (TM) and inappropriate model (IM). This result support the improvement of pre-service physics teachers' conceptual understanding.

Keywords: Level of Understanding; Model of Understanding; Physics teacher

Introduction

Physics is natural science that studied natural phenomena, its interaction in entities of energy and force, and its behavior through space and time, from subatomic to universe scale (Maxwell, 1878; Wulandari et al., 2022). In other words, physics studied about how the way our around world works. In addition, physics extends and enhances of other disciplines understanding, such as biophysics, chemical physics, geophysics, astrophysics, and environmental physics.

The concept of physics included like motion, energy, wave, thermodynamics, electricity, magnetism and modern physics. These concepts are needed and contributed for the future technology advances. Modern physics enable advances in new technologies and become the basis for the most modern technologies (Young & Freedman, 2014). There are many applications of the equipment and technology which resulted from intellectual of human endeavors in physics. Anyhow, phyiscs plays an important role in education as well of other physical sciences (Shishigu et al., 2017). So that, improvement of basic understanding in physics necessary for developing new equipment and technology. Accordingly, this citizens productivity must have a basic understanding of physics.

Understanding is one level of cognitive ability in Bloom's taxonomy. The ability to understand is the ability to transfer knowledge. Physics as science has array of concept and major principle. Concepts are collections of knowledge that are stored in long-term memory and used in processes that underlie higher cognitive competencies (Chen, 2013). Understanding in physics concept is needed to solve the problem in life. In applying conceptual understanding need the techniques and procedures to solve the problems. Conceptual understanding means connecting between new knowledge and prior knowledge, or having interconnected both relate relevant knowledge and discriminates unrelated knowledge. So that, conceptual

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understanding is knowledge that needed to be stored in memory and in efficient ways for recall. Furthermore, Sand stated that that conceptual understanding seems to imply something different from ideas of concept. Conceptual in Physics implies a qualitative approach, but qualitative reasoning does not always predominate in conceptual understanding (Sands, 2014).

The topic of conceptual understanding has been considerable interest for educational research, especially as found in physics (Voss & Wiley, 1997; Saricayir et al., 2016). Anyhow, conceptual understanding helps in solving complex problem (Saputri & Suyudi, 2020). So, physics learning needs conceptual understanding deeply (Oktaviani & Sumardi, 2016). But it found the class focus on how to memorize the equation in practice solving problems without concept cultivation deeply (Patriot, 2019) and the understanding was wrong wasn't inappropriate opinion of expert (Nadhor & Taqwa, 2020). Moreover, students have knowledge in pieces (Hammer, 2020). In order to, the students may fail to grasp new concepts properly (Ausubel et al., 1968) and leads to misconception (Saricayir & Sahin, 2006). Complexity, misconception tends to retention and difficult to change (Berek et al., 2016). The science students are often present into learning by bringing understanding what they gained from previous learning (Cepni & Sahin, 2012; Radovanovic & Slisko, 2013; Dockor & Mestre, 2014). This misconception causes the students tend to use the same knowledge in solving similar problem in various context (Nadhor & Taqwa, 2020) and across some kind of previously unexpected experiences (Smith & Ragan, 1999). Conceptual understanding was defined variously, and often with declarative knowledge learning. In which, students should memorize and entail more that rote memorization of relationship between things, events or process (Darmofal et al., 2002). Association, comparison, assimilation and new knowledge reorganization included to conceptual understanding to solve new problematic problems (Saricayir et al., 2016). Insight about students' conception may help educators in design teaching approaches to target conceptual understanding. So, the aim of this research was to analyze the students' conceptual understanding level. It will help educators in selecting the suitable teaching approaches and strategies to gain conceptual understanding.

Method

This research design used a quantitative-descriptive model. The design aims to describe the conceptual understanding level of pre service teacher on Newton's Laws concept. The subjects were 40 students of Physics Education Department UNSAM who credited Fundamental of Physics course.

Analysis conceptual understanding level and understanding model of pre-service physics teacher used instrument test which developed by Saglam (2010). The test given was Newton's Law concept, it was considered because the students have learned physics since they in junior and senior high school. Further, Robertson et all (2004) stated that Newton's Law is one of basic concept relate to force and motion.

Problem (1)

A. Please describe the movement of a child on a scooter while the scooter is bumping against a barrier.
B. Which laws of physics can explain the movement of the child?
C. There are many more applications of this law that you have explained. Could you give one more example?
D. Please explain this law.

Problem (2)

A. Please consider your experiences about pushing a car that has a dead engine and explain the relation between the cars' acceleration according to the forces applied as $|F1|>|F2|>|F3|$.
B. Which physics' law can be used to explain the variance of acceleration values of the car pushed?
C. Please give an example referring to this law.
D. How can we explain this law?

Problem (3)

A. Please describe the movement of a person who has fired a rifle.
B. Which law of physics can explain this fact?
C. Please give another example confirming the presence of this law.
D. Define this law.

Figure 1. Test Model of Conceptual Understanding Level

Figure 1 show that the test model consists of four opened questions for the students, that is part A, B, C and D. Part A, the students presented the problem or phenomenon of physics in daily life, then the student should give an explanation how it occurs. Part B, the students find the correct concept according to the answer of part A. Part C, requiring the students to write another sample case confirming the presence of the concept which found in par B. Par D, students define the concept according to their answers in part A, B and C. Then, the four answers analyzed collectively to specify the characteristic of conceptual understanding model of each student, showed in Figure 1.

Level of Understanding		Criteria for Scoring
[0]	No response (NR)	• Leaving blank • Answering "I don't know" • Answering "I don't understand"
[1]	No Understanding (NU)	• Complete repetitio • Irrelevant answer • Vague answer
[2]	Incorrect Understanding (IU)	• Insensible information • Incorrect information
[3]	Partial Understanding (PU)	• Answers that include only one aspect but not all aspects of a valid answer • Answers that include some aspects of a valid answer and some misunderstandings
[4]	Sound Understanding (SU)	• Answers that include all aspects of a valid answer

Figure 2. Assessment Rubric of Understanding Level

Furthermore, deduce the level of understanding and model of understanding pre-service physics teacher. Relationship of understanding model with understanding level refer to classification guidelines model of understanding level developed by Saglam, et all (2010), showed in Figure 2.

Model of Understanding	Characteristics	Levels for Items (A, B, C, D)
Optimum Model (OM)	Answers to each of the 4 questions requiring explaining the sample case, determining the law, exemplifying the law and defining the law about any of Newton's Laws of Motion are at level 3 [PU] or level 4 [SU]	$\begin{pmatrix} 3 & 3 & 3 & 3 \\ 4 & 4 & 4 & 4 \end{pmatrix}$
Uncreative Model (UM)	Answers to each of the 3 questions requiring explaining the sample case, determining the law and defining the law about any of Newton's Laws of Motion are at level 3 [PU] or level 4 [SU]. However, the answer for exemplifying the law question is at level 0 [NR], level 1 [NU] or level 2 [IU]	$\begin{pmatrix} 3 & 3 & 0 & 3 \\ 4 & 4 & \frac{1}{2} & 4 \end{pmatrix}$
Theoretical Model (TM))	Answers to the questions requiring determining the law and defining the law about any of Newton's Laws of Motion are at level 3 [PU] or level 4 [SU]. However, the answers for explaining the sample case and exemplifying the law questions are at level 0 [NR], level 1 [NU] or level 2 [IU].	$\begin{pmatrix} 0 & 3 & 0 & 3 \\ \frac{1}{2} & 4 & \frac{1}{2} & 4 \end{pmatrix}$
Practical Model (PM))	Answers to the questions requiring explaining the sample case and exemplifying the law about any of Newton's Laws of Motion are at level 3 [PU] or level 4 [SU]. However, the answers for determining the law and defining the law questions are at level 0 [NR], level 1 [NU] or level 2 [IU].	$\begin{pmatrix} 3 & 0 & 3 & 0 \\ 4 & \frac{1}{2} & 4 & \frac{1}{2} \end{pmatrix}$
Memorizing Model (MM)	Answers to the question requiring defining the law about any of Newton's Laws of Motion are at level 3 [PU] or level 4 [SU]. However, the answers for explaining the sample case, determining the law and exemplifying the law questions are at level 0 [NR], level 1 [NU] or level 2 [IU].	$\begin{pmatrix} 0 & 0 & 0 & 3 \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} & 4 \end{pmatrix}$
Inappropriate Model (IM)	The answers to all 4 questions requiring defining the law, explaining the sample case, determining the law and exemplifying the law about any of Newton's Laws of Motion are at 0 [NR], level 1 [NU] or 2 [IU]	$\begin{pmatrix} 0 & 0 & 0 & 0 \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{pmatrix}$

Figure 3. Classification Model Rubric of Student Mentality

Data analysis break down into two parts. The first, analysis understanding level of pre-service physics teacher with score criteria: [0} No Response (NR); [1] No Understanding (NU); [2] Incorrect Understanding (IU); [3] Partial Understanding (PU); [4] Sound Understanding (SU). The second, analysis understanding model of pre-service physics teacher such as Optimum Model (OM), Uncreative Model (UM), Theoritical Model (TM), Practical Model (PM), Memorizing Model (MM) and Inappropriate Model (IM).

Result and Discussion

Table 1. Level of Understanding Recapitulation of Pre-Service Physics Teacher on Newton's First Law Concept

Level	Newton's First Law			
	A	B	C	D
[0] NR	0	4	0	0
[1] NU	18	14	10	26
[2] IU	38	32	40	20
[3] PU	16	20	26	24
[4] SU	28	30	24	30

Table 1 shows the students' level of understanding level (pre-service physics teacher) on Newton's first law concept. In part A (first question), most of the answers (38%) were classified at the incorrect understanding. Only 28% answers were classified at the sound understanding, the remains were classified at no understanding (18%) and partial understanding (16%). In part B (second question), there are 4% students give no response about the question "which law of physics can explain the case?". However, most of answers only reached 33% that were classified at incorrect understanding. It was insignificant numbers of sound understanding (30%).

Part B reached higher achievement than part A, it occurs because the student could choose the appropriate concept. While in part A student should give an explanation the case knowledge theoretically. In contrast to the result of Saglam's research (2010), where was reached higher numbers in part B about Newton's first law concept. It was because the students were not aware that the case could be explained theoretically.

In part C (third question) requiring students to write another sample case about the newton's first law, most of answers (40%) were classified at incorrect understanding. The remaining responses were partial understanding (26%), sound understanding (24%) and incorrect understanding (10%).

Based on the first three questions showed that the most answer at the incorrect understanding. In part D (fourth question), were mainly classified only 30% as sound understanding about asking definition of the newton's first law. It was insignificant numbers of another at no understanding (26%), partial understanding (24%) and incorrect understanding (20%).

The percentage range of Table 3 show the insignificant numbers among levels. Generally,

students' achievement has no fallen progressively. It explains that students reach success level in almost same numbers. However, the students' reach different success in the questions about conceptual understanding.

Table 2. Level of Understanding Recapitulation of Pre-Service Physics Teacher on Newton's Second Law Concept

Level	Newton's Second Law			
	A	B	C	D
[0] NR	0	0	0	0
[1] NU	12	36	40	30
[2] IU	24	14	20	12
[3] PU	20	18	24	26
[4] SU	44	32	16	32

Student's understanding level related to the Newton's second law concept given in Table 2. It shows that all students give the response to opened questions about Newton's second law. In explaining the case/phenomena (Part A) were classified at no understanding (12%), incorrect understanding (24%) and partial understanding (20%) and sound understanding (44%). It was found most of students were sound understanding in giving scientific explanation. Responses to the second question (Part B), found that most of students at no understanding (36%) and sound understanding (32%), the remains at incorrect understanding (14%) and partial understanding (18%). Its mean, the students were not so aware that the given case or phenomena could be explained theoretically with the Newton's second law. This result show that although the students can explain the case/phenomena (part A) but they didn't aware that it could be explained the concept in physics (part B) and their prior knowledge was not enough to give scientific explanation. Question requiring students to write another sample case related to newton's second law (Part C), it found only 16% at sound understanding. It lower than other levels were classified at partial understanding (24%), incorrect understanding (20%), and no understanding (40%). It means most of them couldn't write another sample case related to Newton's second law. The SU of part A and part B show that the students couldn't answer the question although it's related to procedural question (part A and part B). The final question about Newton's second law definition (Part D), it was found that 32% at sound understanding slightly higher than no understanding numbers (30%). The remaining response were classified at incorrect understanding (12%) and partial understanding (26%).

Over all, at sound understanding, numbers of part A higher that other, it could be because most of students only notice the surface event or case of situations (Shishigu et al., 2017). It probably, rarely investigation in physics education applied an evaluated a teaching sequence, so that students' daily experience has not come into physics knowledge (Lemmer, 2018). It also probably students' prior knowledge which is based their experience contains misconceptions (Dega et al., 2013).

Table 3. Level of Understanding Recapitulation of Pre-Service Physics Teacher on Newton's Second Law Concept

Level	Newton's Third Law			
	A	B	C	D
[0] NR	0	0	0	0
[1] NU	15	8	14	22
[2] IU	10	13	24	21
[3] PU	16	11	8	10
[4] SU	59	68	54	47

Table 3 is the students' understanding level related to the Newton's third law. It found the responses were highest than Newton's first law and Newton's second law. The responses mainly reached 59%, 68%, 54% and 47% at the sound understanding for each part. It probably, the case/phenomena given related in their experience in daily life. Moreover, the responses were classified at no understanding (15%), incorrect understanding (10%) and partial understanding (16%) for responses in explaining the sample problem given (part A). For the second question (part B), about determining the physics law of the sample problem given, were classified at no understanding (8%), incorrect understanding (13%) and partial understanding (11%). The question asked the students to write another sample problem (part C) were classified at no understanding (14%), incorrect understanding (24%) and partial understanding (8%). The last question (part D) in defining the Newton's third law were classified at no understanding (22%), incorrect understanding (21%) and partial understanding (10%).

The subjects of this research are pre-service physics teacher credited Fundamental of Physics course. They learned the concepts of Newton's laws and passed the exam (Feynman, 1963). But here we found that, the student's level of conceptual understanding still low although the students pass the exam. The low of students' understanding level in physics due to their inability to related physics concepts with real life. It show that learning the theory and practice have not a significant impact on increasing the sound understanding of physics concept (Nersessian, 2008).

These low of understanding level could cause the misconception. Anyhow, the lecture should give attention about conceptual understanding. As instructor, the lecture should be able to understand the students as well so that the students can understand learning as well (Arafah & Rusyadi, 2020). The students who possess the understanding can be apply the knowledge and skill of science in the real world (Shishigu et al., 2017). In most cases, the lecture opened the class without consider the initial conceptual

understanding of students. In other words, the lecture treats the students as "empty bowl" who can take over more knowledges until it full to overflow. This view is not accordance to constructivism theory, which is assumes that students have prior knowledge before come to the class (Saputra, 2019). So that, before give a class, the lecture should be better give initial diagnostic test to mapping student's level of understanding, then the lecture could give a sufficient lecture appropriate to student's characteristic. It could help the lecture to make sure that the students understand the physics concept, in other hand the students also can apply the concept in the real world.

Table 4 shown the classifications of determination result of students understanding model. The students' model of understanding was found varying results. Where, 22% observed in optimum model, 10% in uncreative model, 4% in theoretical model, 28% in practical model, 10% in memorizing model, 22% in inappropriate model and 4% in others for the concept of Newtons' first law. It reached insufficient large numbers of scientific knowledge expected related to Newton's first law. The concept of Newtons' second law found that 26% appeared in optimum model, 18% in uncreative model, 3% in theoretical model, 16% in practical model, 8% in memorizing model, 28% in inappropriate model and 2% in others. Most appearing model is inappropriate model. The concept of Newtons' third law found that 18% appeared in optimum model, 16% in uncreative model, 8% in theoretical model, 18% in practical model, 16% in memorizing model, 22% in inappropriate model and 2% in others.

Table 4. Model of Understanding Recapitulation of Pre-Service Physics Teacher

Understanding Model	Newton's First Law	Newton's Second Law	Newton's Third Law
Optimum Model (OM)	22	26	18
Uncreative Model (UM)	10	18	16
Theoretical Model (TM)	4	2	8
Practical Model (PM)	28	16	18
Memorizing Model (MM)	10	8	16
Inappropriate Model (IM)	22	28	22
Others	4	2	2

Most appearing model in this research is inappropriate model. These result show that the most of understanding model was in inappropriate model. So that this result support the improvement of students' conceptual understanding, especially pre-service physics teacher. Anyhow, pre-service teachers should prepare their self in sufficient knowledge to be a decent teacher. The fact about the students' performance in physics is poor for the last twenty years (Stephens et al., 2016), forces education observer to attend the role of teacher in science teaching. In the cases, we can focus and give attention to pre-service science teachers' achievement in development of students' conceptual understanding in physics concepts (Mustafa et al., 2020).

Conclusion

This research show that the students' level of understanding (pre-service physics teacher, UNSAM) was vary about Newton's law concepts but show the insignificant numbers among levels. Generally, students' achievement has no fallen progressively. It explains, students reach different success in the questions about conceptual understanding. While students' understanding models, they most appear in theoretical model (TM) and inappropriate model (IM). This result support the improvement of pre-service physics teachers' conceptual understanding.

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