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Students' Understanding of Newton Dynamics Concept Using Concept Map

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Abstract. This research aims to analyze students' understanding of the concept of Newton's dynamics using concept maps. The method used in this study is a quantitative descriptive method, with data collection techniques using the concept map-making test. This research was conducted at SMA Negeri 21 Palembang with 37 students as participants. The data from 37 student concept maps was reduced because there were similarities, and then 10 concept maps were analyzed. Based on the students' concept maps about Newton's dynamics, many students still did not understand the concept of centripetal force and centripetal acceleration. Most students understand the concept of dynamics and friction. Most students were wrong about the concept of force because students did not connect the concept with the concept of acceleration and mass. Students also found it challenging to determine the most common and inclusive concepts, such as the concept of dynamics as superordinate. Students placed parallel to the concept of speed. No students made cross-link on the concept map. In the sample criteria, most samples produced examples of applying frictional concepts.

Keywords: *Concept Map, Cmaptools, Understanding of Concepts, Newton Dynamics*

INTRODUCTION

Students' concept understanding needs to be emphasized to support the school learning process. Measuring concept understanding using a concept map is a student's understanding of and connecting a concept with another concept using a concept map. It can be generated based on learning development using concept maps expressed from existing concepts [1]. The concept itself is based, among others, on the understanding of content, the level of achievement of science, and the relationship between concepts [2].

The concept map is used as an assessment or formative assessment so that students understand concepts [1]. Concept maps can use paper and pen or take advantage of existing applications. Understanding of concepts can be known according to the results of the student's concept map as a final assessment in the learning process [2]. Concept maps provide researchers in knowing students' understanding of concepts.

Llinás et al. [1] researched using concept maps as physics assessments. Their study showed that students often create still-inappropriate concept maps such as constructed concepts, propositions, and phrases unrelated to the material. Students have not fully understood the concept correctly through the learning process [3]. In line with Suárez, (2020) the purpose of his research is to find out that concept maps can be used to support learning in mechanics concept. There are still many students who do not understand the clarity of concepts and connect concepts correctly [4]. Based on the explanation above, the researcher conducted a study that analyzed students' understanding of Newton's concept of dynamics using a concept map.

METHOD

This research uses quantitative descriptive methods. The existing data was then calculated and then analyzed, and exposed to the data [5]. The results of the presentation are based on the criteria in the assessment of the concept

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map. This research was carried out in two stages: the process of making concept maps (tests) and interviews [6]. This study used the subjects of 37 students in eleven grader in one school in Palembang.

Data collection techniques include tests and interviews. There were 21 concepts used in the process of making concept maps. The interview was conducted to find out and strengthen student understanding about Newton's dynamics. Interviews were conducted after such data had been determined based on the criteria of the concept map [7]. The data analysis technique was carried out by calculating the student's concept map scores using the Novak & Gowin rubric [8]. The calculation results are then reduced to the purpose of the data so that the data can be analyzed and processed in accordance with the study's objectives [9].

RESULT AND DISCUSSION

This study produced 37 concept maps determined based on the Novak & Gowin rubric. This was obtained by 10 concept maps according to the criteria of the most complete concept map of members who have similarities. Concept maps selected 10 groups of concept maps through data reduction and sorted according to concept map scores**.** following are results of 10 concept maps can be seen in Table 1.

TABLE 1. Student Concept Map Calculation Results

	Assessment Criteria				**Total**
	Proposition	**Hierarchy**	***Cross-link***	**Example**	
	(1× …)	(5× …)	(10× …)	(1× …)	
Concept Map 1	1 × 2	5 × 2	10 × 0	1 × 0	12
Concept Map 2	1 × 10	5 × 4	10 × 0	1 × 0	30
Concept Map 3	1 × 6	5 × 4	10 × 0	1 × 0	26
Concept Map 4	1 × 4	5 × 2	10 × 0	1 × 0	14
Concept Map 5	1 × 2	5 × 2	10 × 0	1 × 0	12
Concept Map 6	1 × 4	5 × 4	10 × 0	1 × 0	24
Concept Map 7	1 × 6	5 × 3	10 × 0	1 × 0	21
Concept Map 8	1 × 9	5 × 4	10 × 0	1 × 0	29
Concept Map 9	1 × 8	5 × 2	10 × 0	1 × 0	18
Concept Map 10	1 × 9	5 × 3	10 × 0	1 × 0	24

TABLE 2. Student Proposition Results and Their Frequency

Concept	**Student Proposition Results**	**Frequency**
Dynamics	Valid	
	Dynamics studies motion.	7
	Dynamics studies force.	10
	Invalid	
	Dynamics include weight force, normal force, centripetal force, and rope tension force.	1
	Dynamics studies acceleration.	1
	Dynamics (without connecting words) speed	1
	Dynamics studies radius.	1
	Dynamics studies mass.	1
Force	Valid	
	Force relates to acceleration.	1
	Acceleration relates to time.	1

	Invalid	
	The force of its mathematical equations is static coefficient of friction and kinetic friction.	1
	Force intersects with motion.	1
	Acceleration relates radius.	1
	Acceleration relates mass.	1
	Acceleration relates to position.	1
	Speed is divided into centripetal speed.	8
	Gravitational acceleration is related to centripetal acceleration.	1
	Acceleration is of its kind of centripetal acceleration.	6
	Acceleration is kind of gravitational acceleration.	7
Motion	Valid	
	Motion is related to position.	5
	Motion is related to time.	4
	Invalid	
	Motion is related to speed.	2
	Motion is related to acceleration.	2
	Motion is related with mass.	1
	Motion is related to the radius.	1
Weight Force	Valid	
	Weight force consists of mass.	1
	Normal force consists of the radius.	1
Friction Force	Valid	
	Friction forces are kinetic friction and static friction.	10
	Kinetic friction consists of kinetic coefficients of friction.	5
	Friction statis consists of a static coefficient of friction.	5
	Invalid	
	The friction force relates to the tension force of the rope.	1
	The frictional force is related to the acceleration of gravity.	1

Data Analysis

Concept Understanding Analysis based on Propositions

Analysis based on propositions is carried out by looking at the results of student propositions and then analyzed based on student understanding. Table 2 indicates the results of student propositions analyzed based on valid and invalid propositions. Most students relate dynamics to the concepts of force and motion on the results of student propositions. It can be known that they already know in advance about the dynamics [10]. Some students associate the concept of dynamics with less relevant concepts, such as associating the concept of dynamics with the concept of speed. Students' understanding of the concept of force is still low, showing more invalid results. This is because they do not associate that force with Newton's Law [11]. The student is supposed to associate the force with mass and acceleration. Still, the student relates the concept of force to the weight force, normal force, friction force, centripetal force, and tension force of the rope. The student's conceptual understanding of force is invalid because it relates the concept of force to friction force. The concept of force is supposed to be associated with mass and acceleration [12]. This shows that students still do not understand the concept of force so students associate with frictional forces. Students connect the concept of frictional force students know the concept occurs if there is a touch between two areas.

A student's concept map that associates the concept of force with motion shows a valid proposition. The student knows that force is related to the concept of motion. Force can cause a stationary object to become mobile. Force can also affect moving objects to become immobile [12]. Some students who attributed the concept of motion to the concepts of speed and acceleration as many as two concept maps made such a proposition [13]. This shows that students experience misconceptions about the concept of motion that occur if there is speed and acceleration. The

results of students' understanding of the concept of speed and acceleration of almost all concept maps were invalid—students at most associate the concept of speed with the concept of centripetal speed. Acceleration is connected with the concept of centripetal acceleration. This is because students do not understand the concept of centripetal acceleration. Students attribute centripetal acceleration to the concept of gravitational acceleration. The concept of gravitational acceleration is supposed to relate to heavy forces, while centripetal acceleration has to do with centripetal forces [14].

Concept Understanding Analysis based on Hierarchy

Analysis of concept understanding based on the hierarchy is carried out by looking at the levels of superordinate, subordinate, and coordinates on each student's concept map.

TABLE 3. Student Hierarchy Results and Their Frequency

Hierarchy	Generalitas	Valid	F	Invalid	F
1	Superordinate	Dynamics	9	Dynamics	1
	Subordinate	Force	10	Weight force	1
				Velocity	1
				Position	1
		Motion	6	Acceleration	1
				radius	1
				Mass	1
	Coordinates	Force and Motion	4	Dynamics and velocity	1
				Force, Motion, Radius and Mass	1
				Force, Motion, and Centripetal Speed	1
2	Superordinate	Force	1	Force	9
	Subordinate	Acceleration	1	Motion	1
				Static coefficient of friction	1
				Kinetic coefficient of friction	1
		Mass	0	Weight force	6
				Normal Force	6
				Centripetal force	6
				Rope tension force	6
				Friction force	8
	Coordinates	Acceleration and Mass	0	weight force, normal force, and centripetal force	1
		weigth force, normal force, centripetal force, rope tension force, friction force	1		
3	Superordinate	Motion	5	Motion	5
	Subordinate	Position	5	velocity	5
		Time	4	acceleration	2
				Mass	2
	Coordinates	Position and Time	4	-	-
4	Superordinate	Friction Force	6	Friction force	3
	Subordinate	Static friction	6	Static friction	3
		Kinetic friction	6	Static coefficient of friction	1
	Coordinates	Static friction and kinetic friction	6	Static friction and friction forces	1
				Static friction and static coefficient of friction	2
				Acceleration, friction force and coefficient of friction	1
5	Superordinate	Static friction	5	Static Friction	5
		Kinetic friction	5	Kinetic friction	1

	Subordinat	Static coefficient of friction	4	Rope tension force	1
		Kinetic coefficient of friction	5	Acceleration of gravity	1
	Coordinates	Static coefficient of friction dan koefisien kinetic friction	3	Static friction and normal force	1
				Kinetic friction and friction	1

Information:
F = frequency

Based on Table 3 shows the results of the student hierarchy regarding Newton's dynamic material. Students at most create a valid hierarchy on the concept of dynamics as many as 9 concept maps. On the invalid concept map, the student puts the concept of dynamics parallel to the concept of velocity. On the concept of force, the average student has problems making subordinates of the concept of force. Students group force into kind of forces [15]. The force is supposed to address Newton's laws so the student hierarchy becomes invalid. They make position and time as one coordinate on the concept of motion. This shows that they understand the concept of motion.

Some students write down according to the terms of the hierarchy. Some of them create such invalid hierarchies as they are created without forming superordinates and subordinates. Students put the concepts of force in parallel, which indicates the concept is a single coordinate. Students also put the concept of dynamics in parallel or one coordinate on the concept of speed. It indicates an invalid hierarchy. After the question and answer, students did not understand to put these concepts according to the criteria of the concept map.

The concept of dynamics is supposed to be laid as the most common concept, so that it is made as a superordinate and there is no one coordinate. Something similar is shown in the concept of motion with centripetal speed. The hierarchy shows invalid because motion is more common compared to centripetal velocity.

Concept Understanding Analysis based on *Cross-link* Criteria

There were no students who made a *cross-link* on Newton's dynamic concept map. This is because they do not know the cross-linkage of each concept.

Concept Understanding Analysis based on Sample Criteria

Analysis of concept maps based on examples is used to see the application of concepts in everyday life. Almost all students are able to give examples of the concept of motion; as stated by one of the students "Motion is a change in position, for example, an object that is pushed".

The same thing about the concept of friction force; almost all students are able to explain and give examples of the application of the concept. One of the students stated, "Friction force for example a pushed object has friction between the floor and the surface of the object". This is a valid example but they don't put it into a concept map worksheet [16].

The results of the concept understanding analysis based on concept map criteria show the low score of the student's concept map. This is because there is no concept map learning in the school [17]. In the implementation of the research carried out, there are also limitations in the time in making concept maps. Based on the resulting proposition, some students experienced not understanding concepts and misconceptions [18]. One of them is indicated in the concept of speed should be connected with the concept of acceleration. Students experience conceptlessness because of eliminating the concepts of force and acceleration. This is related to the results of Gates (2014) through experiments resulting in better student understanding [12]. Force is related to motion, while acceleration of its relationship with force occurs if it is unbalanced. Students' understanding of Newton's second law is also still low because it is unable to explain the concept of the force that causes objects to have acceleration. The student omits the concept of force that should be above the concept of acceleration [12].

There are students who don't understand concepts at all. This can be seen when they ask questions and answers with researchers. The student experienced problems in connecting between concepts [19]. On this issue, the researcher experienced results that were in line with previous research on developing an understanding of electromagnetism, namely that it was difficult to find a link or connect between concepts, and the understanding of concepts was good, it was just difficult to explain concepts in their own words through [19].

The results of a similar study from Maker & Zimmerman (2020) whose purpose is to test the assessment of students' science concept maps in three schools including produced from the aspects of propositions, hierarchy, crosslinks and examples of school C are good in all aspects except for hierarchical scores but other schools have sufficient only a few aspects [2]. Students produce the most valid criteria on propositions and examples [20]. In the

hierarchy criteria, students experience obstacles in placing concepts based on generalities including superordinate, subordinate, and coordinates.

CONCLUSIONS

Based on data analysis from the result and discussion, it can be concluded that students' understanding of the concept of Newtonian dynamics is still low. This is seen based on the analysis of understanding the concept from the results of the concept map he made. Almost all students do not understand the concept of centripetal force, and the centripetal acceleration. Students predominantly understand the concepts of motion, force, rope tension, and friction force. Some of them experience obstacles such as: eliminating concepts from worksheets, namely the concept of radius, centripetal acceleration, and centripetal force. This shows that students do not know some of the concepts contained in the worksheet. Students who experience the most difficult problems find connective words and put concepts based on the terms of the hierarchy. Students understand the most in providing examples of the application of concepts, namely in the concepts of motion, friction force, and rope tension force.

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