

Analysis of Students' Knowledge Sources (Resource Theory) in Rolling Motion Context and Its Implementation in Physics Learning

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Abstract

Resource theory is a cognitive theory that can explain students' difficulties in understanding physics concepts and be a basis for developing meaningful physics learning. However, studies on resource theory have been used more to analyze learning difficulties and identify student resources only. Through this research, we developed an inquiry-based learning model by considering students' initial resources, implement it, and see resource changes after learning. This article describes changes in students' resources regarding the phenomenon of rolling motion from before to after learning. The research subjects were 32 students of class XI MIPA at Senior High School. Student resources were identified based on student's answers to the pretest and posttest using a reasoned multiple-choice instrument, then analyzed qualitatively using a constant comparison technique. Several resources were revealed based on students' reasons for their answers during the pretest, all classified as phenomenological primitives. Based on students' reasons for their answers during the posttest, it can be concluded that learning can help most students organize scientific resources and identify the context in which they can be used.

Keywords: Physics, Physics Learning, Resource Theory, Rolling Motion, Understanding Concepts.

INTRODUCTION

Effective physics learning can be viewed as a process of building an understanding of concepts that are hierarchically interconnected and can be applied contextually to explain and predict natural phenomena. A good understanding of these concepts is very necessary for explaining physical phenomena in everyday life, identifying problems, solving physics problems, and developing appropriate problem-solving strategies (Docktor et al., 2015; Mason & Singh, 2006). It makes physics more than just memorizing mathematical equations. Previous studies have shown that many students have weak conceptual understanding because they often only memorize formulas without

conceptual meaning, resulting in poorly connected knowledge and difficulty integrating it into different contexts (Bao & Koenig, 2019). In the context of understanding concepts, physics learning is said to be successful if it can facilitate students: (1) understanding the physics knowledge being studied and being able to relate it to other relevant physics knowledge, (2) being able to connect the knowledge they learn with everyday physics phenomena, and (3) can explain when and how the physics concepts that have been studied can be used (Redish, 2003).

It is not easy to help students master physics, especially physics material that is abstract and complex, such as rolling motion, which is included in the sub-concept of rotational

dynamics. Research shows that even though students have studied this material in physics classes, many still struggle to apply the concepts they have learned. Specifically, the difficulties that arise in the context of rotational dynamics that were revealed by previous researchers include difficulties in drawing force diagrams that cause objects to rotate (Ayesh et al., 2010; Carvalho & Sousa, 2005), determining the linear speed of rotating objects (Mulyastuti et al., 2016; Syahrul & Setyarsih, 2015; Ambrosis et al., 2015), distinguishing torque from force (Rimoldini & Singh, 2005), and determining the magnitude and direction of torque (Sarkity et al., 2016; Syahrul & Setyarsih, 2015).

Students' difficulties in mastering and applying new concepts learned are generally explained using misconception theory. According to misconception theory, often students come to physics class with misconceptions that they build themselves based on their experiences. Misconceptions resulting from early experiences are called preconceptions (Suparno, 2013). These preconceptions are often acquired from the surrounding environment, parents, and peers through their experiences and interactions in everyday life. It causes misconceptions to become deeply ingrained. The misconceptions that students carry are stable and tend to interfere with students constructing new (true) knowledge and defeating this new knowledge in solving problems. Therefore, misconception theory suggests that students' misconceptions must be removed first and then replaced with scientific conceptions as agreed by experts

(Docktor & Menstre, 2014; Suparno, 2013). Adherents of misconception theory offer learning based on cognitive conflict strategies to replace misconceptions with correct understanding (Rahim et al., 2015; Mulyastuti et al., 2016; Hadjiachilleos et al., 2013; Foster, 2012; Kabaca et al., 2011). In principle, eliminating and replacing misconceptions with correct conceptions will only occur if students experience cognitive conflicts about the truth of their preconceptions. Therefore, teachers must encourage students to activate various types of students' preconceptions during learning (Richards et al., 2020). Even though, theoretically the cognitive conflict strategy is effective in overcoming misconceptions, it is not easy to implement in learning. Learning strategies that teachers believe can create cognitive conflict in students often do not cause significant cognitive conflict. As a result, efforts to eliminate misconceptions have yet to be successful.

A new theory has recently developed, namely resource theory (diSessa, 1993; Hammer, 1996). This theory then explains students' difficulties in understanding physics ideas. Resource theory does not believe in the existence of stable misconceptions as believed by misconception theory. This misconception theory is not stable and solid but is still fluid and depends on context. Based on resource theory, students' failure in explaining physics phenomena is not always caused by students' physics knowledge being completely wrong but rather due to the activation of pieces of knowledge (knowledge in pieces) that are not

appropriate to the context (diSessa, 1998; Docktor & Menstre, 2014; Hammer, 2000). The knowledge students use in answering questions often depends on the context of the problem and the questions given (Taqwa & Rivaldo, 2018). These pieces of knowledge may have truth value in certain contexts, but students tend to use them in all contexts. The use of pieces of knowledge that are irrelevant and not appropriate to the context is because students do not understand and master certain concepts and formulas (Nadhor & Taqwa, 2020). In explaining physical phenomena, students generally use resources that diSessa (1998) calls phenomenological primitives (p-prim), obtained through students' real experiences in everyday life, without going through sufficient abstraction.

Based on resource theory, the teacher's task is to help students perfect their primitives from being phenomenological to more scientific. Based on this idea, many researchers believe resource theory is easier to apply than misconception theory to improve students' understanding (Fotou & Abrahams, 2016; Jones & Zollman, 2014). However, research related to resource theory is generally limited to identifying learning difficulties (Jones & Zollmann, 2014; Fotou & Abrahams, 2016; Sabo et al., 2016; Rahmawati et al., 2017). It is still rare to find research directed at designing student resource-based learning. There needs to be learning based on student resources to help students assemble and perfect the pieces of their knowledge to form a complete concept and increase their understanding of concepts (Mulyastuti

et al., 2017).

In this research, we have implemented physics learning based on resource theory in learning rolling motion. Before learning, we identify student resources through the reasons for students' answers during the pretest, especially phenomenological resources (p-prim). The results of this pretest are then used to design learning so that students can refine their p-prim into a more scientific resource. In this study, the results obtained were the types of p-prim activated by students and the shift in student resources before and after learning took place. Considering the wide range of aspects that emerged during the research, this article is focused on describing changes in students' resources related to rolling movements. Two main themes will be explained: the kinematics of rolling motion and the dynamics of rolling motion.

METHOD

The research method used was a qualitative method with a constant comparative technique. This technique was used to compare student resources before learning (through pretest responses) and after learning (through posttest responses). The research subjects were 32 students of class XI MIPA Senior High School. Students' initial resources are explored through a conceptual understanding test using a reasoned multiple-choice instrument. Resources were obtained from the rationale section of students' answers during the pretest and analysis of learning recordings, especially students' answers when asked to explain the

phenomena presented in the lesson. Student resources after learning are explored through a posttest, which is given after the entire rolling movement learning unit has been completed. The questions used in the posttest are the same as those used in the pretest. The test questions related to the focus of this article consist of 3 questions: two questions for the kinematics of rolling motion (Figures 1 and 2) and one question for the dynamics of rolling motion (Figure 5).

Analysis of student answers on the pretest and posttest using constant comparative analysis techniques (Anderson & Wall, 2015; Demirdogen, 2016). First, students' answers are grouped roughly based on similarities to obtain several initial categories. The initial categorization results are further refined (split or combined) to get the smallest possible number of categories but represent all existing variations. The final category is then labeled as student resources. Data analysis of learning recordings is carried out through transcription of the recordings and then creating categories to obtain a variety of thoughts that reflect student resources.

RESULT AND DISCUSSION

RESULT

1. Students' Resource on Rolling Motion Kinematics

Students' resources related to the kinematics of rolling motion are explored with two isomorphic problems, as presented in Figures 1 and 2. These two problems relate to variations in the linear velocity of points on a rigid body

rolling without slipping. The first question (Figure 1) is presented in the context of everyday life, while the second question (Figure 2) is presented in a more technical context (using scientific technical terms in physics). The following shows the changes in student resources from when they took the pretest to when they took the posttest.

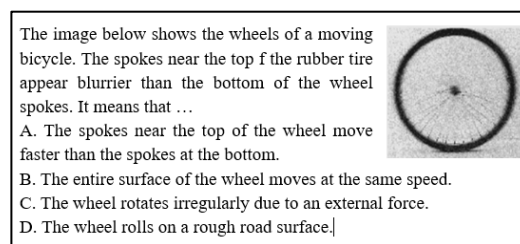


Figure 1. Problem 1 related to rolling kinematics

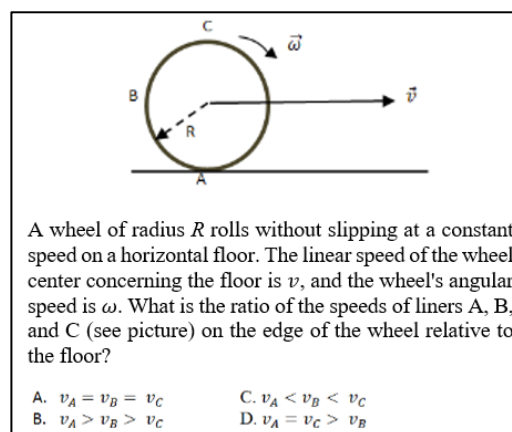


Figure 2. Problem 2 related to rolling kinematics

A summary of changes in student resources from the time of doing the pretest, during learning, to the time of doing the posttest can be seen in Table 1 (questions 1 and 2)

2. Student Resources on Rolling Motion Dynamics

Student resources related to the dynamics of rolling motion are explored using questions as presented in Figure 3. This question is related to the linear

speed of a rigid body rolling from the top of an inclined plane. The following shows the changes in student resources from when they took the pretest to when they took the posttest. A summary of changes in student resources from the time of doing the pretest, during learning, to the time of doing the posttest can be seen in Table 1 (questions 3)

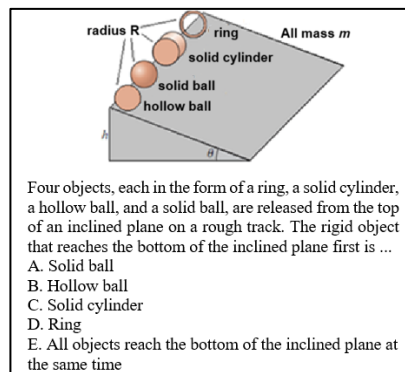


Figure 3. Problems related to rolling motion dynamics

Table 1. Student resources on the material kinematics of rolling motion (questions 1 and 2) and dynamics of rolling motion (question 3)

No	Resources activated during the pretest	Resources activated during learning	Resources activated during the posttest
1	<p>Closer is stronger (11 students)</p> <hr/> <p>Higher is falls faster (8 students)</p> <hr/> <p>Friction force inhibits the motion of objects (2 students)</p>	<p>Rolling motion is a combination of translational and rotational motion</p>	<p>The type of rolling motion is a combination of translational motion and rotational motion. The linear velocity of a rolling object is a combination of the linear velocity of translational motion and the linear velocity of rotational motion (28 students)</p>
2	<p>One system moves equally fast (1 students)</p> <hr/> <p>The higher an object, the slower the object's movement becomes (12 students)</p>	<p>Linear speed in rolling objects it is a combination of linear speed in translational motion and linear speed in rotational motion</p>	<p>Linear speed in rolling objects it is a combination of linear speed in translational motion and linear speed in rotational motion (14 students)</p>
3	<p>Heavy objects fall faster (9 students)</p> <hr/> <p>Light object is easier to move (3 students)</p> <hr/> <p>A wide surface is more stable when rolling (5 students)</p>	<p>Heavy objects fall faster</p> <hr/> <p>Light object is easier to move</p> <hr/> <p>Friction inhibits movement</p>	<p>Rolling motion is a combination of translational and rotational motion. Mechanical energy applies in the context of an inclined plane with kinetic energy in rolling motion being the sum of translational kinetic energy $\frac{1}{2}mv^2$ and rotational kinetic energy $\frac{1}{2}I\omega^2$ (16 students)</p>

DISCUSSION

The discussion will be carried out in each sub-chapter: (1) kinematics of rolling motion and (2) the dynamics of rolling motion.

1. Students' Resource on Rolling Motion Kinematics

a. Resources Activated During The Pretest

Student resources can be seen in Table 1. Regarding Question 1, most students (21 out of 32) gave the reason that the top spokes looked blurry: they were moving faster than the bottom spokes. At first glance, the student's answer seems correct. However, after looking closely at the argument, it appears that students only rely on primitive phenomenology: "The faster the object moves, the more difficult it is to recognize its shape." There are three types of resources (all of which fall into the p-prim category) that students use: (1) "closer is stronger," (2) "higher falls faster," and (3) "friction forces inhibit the movement of objects." Below is a student's initial resource explaining why the top bars are faster than the bottom bars.

Closer is Stronger

The resource "closer is stronger" is obtained from student arguments, namely:

"The spokes on the top wheel look blurry because it is moving faster. This is because the top spoke is closer to the center of rotation."

A total of 11 (out of 21) students activated this resource. They think the closer to the center of rotation, the stronger or greater the resulting speed.

Higher is Falls Faster

The student resource "higher is falls faster" was identified from student arguments:

"The top bar moves faster because it is higher than the bottom bar."

As many as 8 out of 21 students thought that the higher an object's initial position, the greater its speed when it fell. This knowledge resource is correct when activated in the context of a free-falling object, where the speed when it hits the ground will be greater than if the initial position was lower.

Friction Force Inhibits the Motion of Objects

The student resource "friction force inhibits the motion of objects" was identified from the following excerpt from student answers.

"The bottom surface of the tire touches the road surface so it moves slowly because it rubs against the road. This causes the top wheel to move faster than the bottom wheel."

As many as 2 out of 21 students thought the part that touched the road asphalt would have a frictional force that would hinder movement. The parts that do not touch the road asphalt do not experience frictional forces, so they can move faster. Interpretation of the findings is carried out using logic and existing theories. As has been explained, all the resources activated by students constitute correct knowledge in their respective contexts. However, students use them in inappropriate contexts.

Regarding question number 2, none of the students answered correctly, and only 13 students (out of 32) gave reasons. Student resources can be seen in Table 1. From the 13 students, one

student chose answer A, and 12 students chose answer B. Based on the students' reasons, two types of resources were identified, namely: (1) "a system moves equally fast" and (2) "the higher the object moves, the slower it is." The following is a presentation of the answers, reasons for the answers, and identified student resources.

One System Moves Equally Fast

Students who activate this resource choose answer A with an answer quote, namely:

"Because the wheels are one unit, the wheels move together and have the same linear speed."

Only 1 in 13 students activated this resource. Students assume that the rolling wheels are in one system, so the linear speed at each point is the same.

The Higher An Object, The Slower The Object's Movement Becomes

The resource activated by students who choose this answer is "the further up you go, the slower the movement of objects." The following is an excerpt of the reasons for the students' answers,

"Because the direction of rolling is from A to C. The further up you go, the slower the wheel moves."

Students who activated the resource chose answer B, with a total of 12 out of 13 students. Students think that the linear speed at point A (the lowest point) is greater than at other points. The direction an object rolls determines the magnitude of its linear speed. When the wheel moves up, the wheel movement becomes slower. Through this thinking, resources that students activate can be identified, namely the phenomenon of

upward vertical movement that students often encounter in their lives. If an object is thrown vertically upwards, the higher it goes, the slower its movement will be. This knowledge resource is correct but is activated in an inappropriate context. This knowledge resource is constructed very phenomenologically by students. This knowledge falls into the p-prim category (diSessa, 1993; Hammer, 1996).

Based on this analysis, it appears that students do not see any similarity in the physics concepts underlying the two questions. Therefore, they responded to the two questions in different ways. Small changes presented in the context will produce different responses, answers, and reasoning patterns in students (diSessa et al., 2004; Dufresne et al., 2002). It follows the resource theory that students' knowledge resources are dynamic and activated depending on the context (diSessa, 1998; Docktor & Menstre, 2014; Hammer, 2000; Sabo et al., 2016). All resources that students activate during the pretest are classified as p-prim.

b. Resources Activated During Rolling Kinematics Learning

The shift in student resources during the pretest to the posttest cannot be separated from the role of resource theory-based learning given to students. The lesson aims to enable students to explain variations in the linear speed of points on a rolling rigid body. Learning is given by demonstrating a wheel rolling on a flat surface. Students are asked to analyze what movements objects experience and how they move. All students activated the resource "rolling motion is a combination of

translational and rotational motion." This resource is identified through student answers, namely:

"Because the wheel is rolling, it combines translational and rotational motion. Translational movements carry out changes in position."

This knowledge resource is the correct resource. This knowledge was obtained from lessons learned at the previous meeting, which discussed rotational and rolling motion kinematics. However, when students are asked to describe the direction of motion, they can only describe the direction of translational motion, not the direction of rotational and rolling motion, as shown in Figure 4. This is because translational motion is discussed more in previous physics material, so students' knowledge resources about translational movements are more dominant and more easily activated.

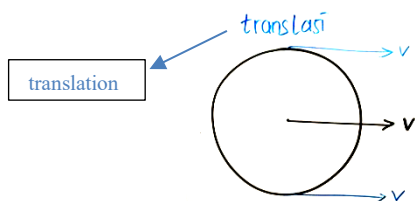


Figure 4. Answers of Student 1 (blue marker) and Student 2 (black marker) regarding the direction of translational motion

Through this demonstration, the teacher confirms concepts related to the demonstration, namely regarding the direction and magnitude of the linear speed of a rolling object, as seen in Figure 5. Rolling motion is a combination of translational and rotational motion, so this also applies to the concept of linear velocity in rolling motion. Linear

velocity in a rolling object is a combination of linear velocity in translational motion and linear velocity in rotational motion (Giancoli, 2014). Apart from confirming the concept, the teacher also provides discussions with students about the linear speed of wheels at several points on a rolling object. This discussion also involved students' knowledge resources, activated when working on Questions 1 and 2 during the pretest. This discussion was carried out to determine the suitability of the knowledge resources activated by students in the expected context.

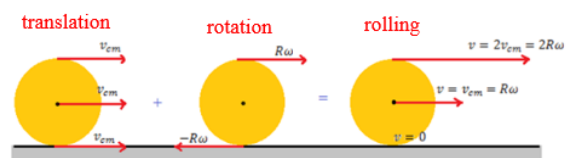


Figure 5. Direction and magnitude of the linear speed of rolling motion

c. Resources Activated During The Posttest

Regarding question number 1, the majority of students (28 out of 32) have succeeded in answering correctly and activating the correct scientific resources, namely: (1) "The type of rolling motion is a combination of translational motion and rotational motion," and (2) "linear speed in rolling objects it is a combination of linear speed in translational motion and linear speed in rotational motion." The following are excerpts from the answers given by students:

"The spokes near the top wheel move faster than the bottom, this is because the running wheel is a combination of translational and rotational motion with a speed at the top of 2v and the bottom of zero. Because it is

rolling, the top wheel moves faster so it runs away."

The students' connected and activated resources for these two reasons are similar. Students who answer correctly have activated and assembled the appropriate scientific resources obtained during learning according to the context.

Regarding question number 2, 14 (out of 32) students answered this question correctly and activated scientific resources. The scientific resource students activate is "the linear speed of a rolling object is a combination of translational motion and rotational motion." The following is an excerpt of the reasons for the student's answers,

"Because the object is rolling and its speed is the combined speed of translation and rotation, v_c is greater than v_B and v_A ."

Students succeeded in activating the right knowledge resources to solve the problem. Based on this idea, the learning provided has succeeded in making students activate and assemble knowledge resources that are appropriate and appropriate to the context.

2. Student Resources on Rolling Motion Dynamics

a. Resources Activated During The Pretest

Student resources can be seen in Table 1. Students' initial resources were revealed through pretest questions, as seen in Figure 3. Some (17 out of 32) students gave answers, while others did not answer. Of the 17 students, nine answered A, three answered B, and five answered C. In this problem, 17 students' answers provided three types of identified resources, namely: (1) "heavy

objects fall faster," (2) "light objects is easier to move," and (3) "A wide surface is more stable when rolling." Below are some student answers and resources that can be analyzed.

Heavy Objects Fall Faster

Some (9 out of 17) students activated the knowledge resource "heavy objects will fall faster." The student who activated the resource chose answer A, namely a solid ball. The following are excerpts from students' answers,

"Because the object is spherical and solid. The ball shape makes it easier for objects to roll and solid objects are heavier."

Students who choose this answer assume that a solid ball-shaped object will be heavier and reach the bottom of the inclined plane first. This knowledge resource is not wrong but can become right if activated in the proper context. It is correct when activated in the context of rocks and feathers dropped from the same height, taking into account air resistance (Fotou & Abrahams, 2016).

Light Object is Easier to Move

A total of 3 (out of 17) students were identified as activating the knowledge resource: "Light objects move more easily." Students with this resource choose answer B, namely a hollow ball. The following is an excerpt of the reasons for the answers given by students:

"Because it is shaped like a ball, which rolls easily. "Apart from that, the ball is hollow, so the ball is light and glides more easily."

Students who choose answer B think that a hollow ball will be lighter, making it easier to move and get to the bottom of the inclined plane first.

A Wide surface is more stable when rolling.

Five of the 17 students chose the solid cylinder answer with the identified resources, namely: (1) "objects with a wide surface are more stable and roll straight," (2) "heavy objects fall first." This resource is obtained through the reasons for the answers written by students, namely:

"The object is cylindrical so it glides more stably, besides that the object is also solid so it is heavier."

Students assume that cylindrical objects will slide more stably. Objects with a wide surface will have a straighter path to reach the bottom of the inclined plane first. Students also assume that solid objects are heavier, so they will reach the bottom of the inclined plane first. The student's answer is wrong, but the activated resource does not mean it is wrong.

These three activated student resources are not appropriate for explaining the context of the given physics problem but have truth value in certain contexts. They are not yet scientific and are still in the form of p-prim.

b. Resources Activated During Rolling Motion Dynamics Learning

To shift resources from pretest to posttest, learning based on resort theory is provided by presenting the phenomenon of two types of objects rolling from the top of an inclined plane simultaneously. Students are asked to determine which object reaches the bottom of the inclined plane first.

The first phenomenon uses two solid cylindrical objects with the same radius.

However, different masses and the second phenomenon use two different objects, namely a solid cylinder and a hollow cylinder. Three types of resources are activated by students, namely (1) "heavy objects fall faster," (2) "light objects move more easily," and (3) "friction forces inhibit movement." These three resources are the same as those activated by students when answering pretest questions and are classified as p-prim because they are obtained from students' daily experiences. The following is a resource description based on students' arguments.

Heavy Objects Fall Faster

In the two phenomena presented, most students (29 out of 32) activated the resource "heavy objects fall faster." This resource can be obtained through student arguments, namely,

"Heavier objects will reach the bottom of the inclined plane first" (phenomenon 1).

"The solid cylinder will reach the bottom of the inclined plane first because the solid cylinder is heavier than the hollow cylinder" (phenomenon 2).

After confirmation, students think that objects with a greater mass will have a stronger gravitational force from the earth, so their pulling force on the earth is greater and they will reach the bottom of the inclined plane first. This student's answer must be corrected, but the activated knowledge resource is correct. This resource becomes correct if activated in the context of a stone and a piece of paper being dropped simultaneously from the same height and considering air resistance (Rahmawati et al., 2017).

Light Object Is Easier to Move

Three other students activated different resources during learning, namely, "Light objects will move more easily." The following are excerpts from student answers:

"lighter objects get to the bottom of the inclined plane first. For example, two people, a fat body and a thin body, are asked to run a race, then the person with the thin body will win because that person moves more easily and does not support his body weight much" (phenomenon 1).

"Objects with a smaller mass will reach the bottom of the inclined plane first because they are light and easier to move" (phenomenon 2).

In this case, the activated student resources are obtained from their experiences in everyday life. Even though the reason for the student's answer is wrong, the resource that the student activates is not simply wrong.

Friction Inhibits Movement

The third phenomenon involves using two solid cylinders with the same mass but different radius. All students agreed with one of the students' answers, which activated the resource "friction as an obstacle to movement." The following is a description of student resources. This resource is identified through student arguments, namely:

"Objects with a larger diameter will have a cross-section in contact with a smaller inclined surface so that the object reaches the bottom of the inclined plane first."

Students assume that objects with a smaller diameter will have a longer shape, so the friction force produced between the solid cylinder and the inclined plane is also significant. Friction

forces the object to get to the bottom of the inclined plane first. Through students' answers, it can be seen that the dominant resource activated by students is knowledge about friction, which is an obstacle to movement. These student resources are correct but are not appropriate when applied to the context of the problems presented. This resource is similar to the one students activated during the pretest on Question 1. Students who activated this resource on Question 1 also activated the same resource on this question. This shows that one resource can be used in several contexts, and students tend to use one resource in all contexts.

The fourth phenomenon uses two solid cylinders with different masses and radii. The activated knowledge resources are consistent as in the three phenomena presented previously. Several students (29 out of 32 students) activated the resources (1) "heavy objects fall faster," and (2) "friction forces inhibit movement" with student answer quotes, *"An object with a greater mass and radius will reach the bottom of the inclined plane first because the object is heavier."*

Several others (3 out of 32 students) activated the resource "light objects move more easily" with quotes from students' answers, namely:

"Objects with a smaller mass will reach the bottom of the inclined plane first because they are light and easier to move."

After knowing the students' initial knowledge resources regarding the dynamics of rolling motion, the teacher confirms the correct answers and concepts to use in explaining the given phenomenon. During the lesson, the teacher and students discuss the

suitability of students' knowledge resources in explaining the presented phenomena.

c. Resources Activated During The Posttest

When the posttest was given, students succeeded in shifting p-prim resources into scientific resources to solve problems, as presented in Figure 5. The scientific resources that were activated: (1) "rolling motion is a combination of translational and rotational motion", (2) "kinetic energy in rolling motion is the sum of translational kinetic energy $\frac{1}{2}mv^2$ and rotation $\frac{1}{2}I\omega^2$ ", (3) "mechanical energy in the context of an inclined plane." These resources were activated by some students (16 out of 32) who answered correctly, while others did not answer. The following are some excerpts of the reasons for students' answers,

"Because the inertia constant k of the solid ball is smaller than the others, the solid ball has a large speed v ."

"Total Kinetic Energy (KE) = KE translation + KE rotation. By using the mechanical energy approach on an inclined plane, we obtain: $mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$. So we get

$v = \sqrt{\frac{2gh}{1+k}}$. It can be concluded that the speed v is inversely proportional to the constant of the type of object k ."

The two reasons for the answers above involve resources similar to those that are activated and connected correctly. This is in accordance with the scientific concept that in rolling motion, mechanical energy is a combination of kinetic energy and potential energy, with kinetic energy which can then be

described as the sum of translational and rotational kinetic energy (Giancoli, 2014).

By shifting students' answers from the pretest to the posttest, the learning provided can build scientific resources and assemble students' knowledge resources. This allows students to solve the physics problems given and use the range of resources they already have. In addition to classroom learning, students need to be given in-depth material, follow-up questions, and teacher feedback to practice the knowledge they have acquired (Nadhori & Taqwa, 2020).

CONCLUSION

This study revealed that students tend to activate one dominant context (resource) to solve all problems they encounter. The resources activated are also phenomenological primitives (p-prims) derived from everyday life experiences, not scientific resources. Learning designed through initial resource detection (during tests) on rolling motion enables students to correctly activate scientific resources according to the presented context. It can be concluded that resource theory-based learning can help students improve conceptual understanding by assembling knowledge resources (to form a unified whole) and accustoming students to using the scientific resources they already possess.

The results of student resource detection in this study can contribute as a reference for educators designing more systematic, meaningful, and coherent physics lessons, especially for similar material. This study is limited by the

material context and sample size. Future research can be conducted on a broader sample and can also be conducted by adding learning interventions based on misconception theory to compare the results of interventions between misconception theory and resource theory.

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