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RESEARCH ARTICLE

The Effectiveness of Concept Cartoons to Enhance Conceptual Understanding of Kinematic Concepts

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Abstract

Understanding kinematic concepts is essential for students to develop a strong foundation in physics and to appreciate the basic principles of nature. This study aims to investigate the effectiveness of concept cartoons in enhancing the conceptual understanding of kinematic concepts among students. This research is an experimental study using a pretest-posttest control group design with two class VII of junior high schools as samples. In both classes, learning was carried out on the topic of kinematics, where the experimental group was given treatment in the form of implementing concept cartoons embedded in worksheets and the control group only used structured worksheets with the same learning model. Based on the results of the pretest and posttest using a reasoned multiple choice objective test instrument, a normalised average gain value was obtained which shows the effectiveness of increasing students' conceptual understanding in both classes after being given treatment, with the experimental group achieving a 0.45 (medium category) normalised gain, higher than the 0.13 (low category) gain in the control group. The statistical test results of the t-test showed that there was a statistically significant difference in enhancement of students' conceptual understanding about kinematic concepts between the experimental group and control group. In addition, during the learning process, students in the experimental group appeared to be more active in discussions. By using concept cartoons, teachers can identify misconceptions experienced by students.

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INTRODUCTION

Kinematics is a topic of physics that explains how objects move without consideration for the causes and effects of the motions (Syuhendri, 2021). The basic concepts of physics studied in kinematics such as distance and displacement, velocity and speed, acceleration, vertical and horizontal motion, uniform straight motion, uniformly accelerated linear motion, and free-fall motion. Furthermore, these concepts are related to gravity and Newton's law. Before going on to more complex physics subjects, students must understand the foundational concepts of kinematics. Although it is a fundamental concept in physics, previous studies have shown that understanding kinematics is still a challenging subject for many students (Muzakki et al., 2022; Taqwa et al., 2022), and there are still many misconceptions found in students related to kinematics concepts (Adam et al., 2023; Gumay, 2021; Khoirunnisa et al., 2024; Nasution et al., 2021; Rohmah et al., 2019; Wells et al., 2020). Therefore, the difficulties that students experience in various kinematic concepts have encouraged researchers to examine why students experience these difficulties and how to overcome them.

According to the Indonesian curriculum, students learn about kinematics in the seventh grade of junior high school, while their capacity for abstract thinking skill is still developing. Moreover, they can comprehend logical concepts and start to use scientific reasoning. When participating in learning, students already have the concept of knowledge obtained from the environment. The concepts that students bring can be in line or not in the same way as scientific concepts (Ozdemir, 2022). During learning, students connect their existing knowledge with new knowledge. If there is a difference between the concept that a person understands and the concept understood by scientists, it can be said that the person has a misconception (Defianti & Rohmi, 2021). Misconceptions are 'dead ends' and students must eliminate their misconceptions to learn the 'correct concept' (Gilbert & Watts, 1983). Therefore, kinematics learning must emphasize conceptual understanding so that students do not have misconceptions in explaining the phenomena that exist around them.

Learning is not simply storing new knowledge and replacing old with new, but there is a strong cognitive interaction between old and new knowledge (Ozdemir, 2022). That means, when learning physics, individuals reconstruct their knowledge of the nature and make their own sense by drawing on what the teacher suggests, their entire prior knowledge, developed skills, views, etc. Therefore, to improve students' understanding of the topics covered, classroom instruction must provide chances for students to actively participate in developing, exploring, explaining, elaborating, and applying physics concepts in everyday life. Real phenomena that occur around students will not be easily understood if only in the form of abstract illustrations in the mind. This requires a learning media that helps illustrate everyday phenomena that elevate the concepts being learnt.

Any tangible or digital resource that teachers employ to help students learn content more quickly and effectively is referred to as learning media (Puspitarini & Hanif, 2019). Media can be used in science classrooms to convey messages, pique students' interests, and try to promote the occurrence of a deliberate, intentional, and controlled learning process. In order to guarantee that pupils precisely comprehend basic scientific concepts and foster critical thinking, creativity, and environmental awareness, it is imperative that educational materials are used appropriately (Widyaningrum et al., 2022). Concept cartoons are among the mediums that can be very useful for students to visualise concepts, participate actively in class, and defend their positions, according to research by Akbaş & Kılıç (2019). Concept cartoons, which were first created in the early 1990s by Stuart Naylor and Brenda Keogh, are cartoon-style illustrations that depict various people debating about commonplace situations. They serve as visual representations of science concepts. Concept cartoons, like the one in Figure 1, give an argument a visual representation that motivates students to interact with and expand on it (Keogh & Naylor, 1999). Concept cartoons are first intended to be used as a tool to introduce concepts to pupils, stimulate their thought processes, and assist them in expanding their comprehension (Naylor & Keogh, 2013). The number of characters in the concept cartoons varies depending on the alternative conceptions that students have about the concept. Alternative conceptions are obtained from the literature on possible student misconceptions in the topics to be presented.

Figure 1. Sample of concept cartoons developed by Keogh and Naylor (1999)

Concept cartoons suggest an innovative teaching and learning strategy based on a constructivist approach to science learning (Keogh & Naylor, 1999). Yin et al. (2016) describe this strategy as using cartoons to present real-life scientific problems with characters expressing various viewpoints. One viewpoint aligns with scientific consensus, while others represent common misconceptions. This approach exposes students to different ways of thinking and addresses their misconceptions (Atchia & Gunowa, 2024), investigating the reasons behind these misconceptions in the classroom (Estacio et al., 2024). Concept cartoons can be developed as worksheets or posters (Atasoy & Ergin, 2017), used as a teaching method or instructional tool in science classes (Akbaş & Kılıç, 2019), and serve as an effective communication tool with an educational purpose (Inan & Kaya, 2017). Additionally, they can function as an assessment tool (Estacio et al., 2024). Therefore, concept cartoons can be employed as a stand-alone learning tool or alongside other strategies.

Student-centred learning, the cornerstone of the constructivist approach, is widely applied in the present scientific curriculum. Examples of this include the usage of problem-based learning models and 5E or 7E learning cycles (Balta, 2016). Put differently, the science curriculum relies on methods that allow students to actively engage in class discussions and build new knowledge from what they already know. Among the many constructivist learning models, a number of studies have demonstrated that the 7E learning cycle model, when applied in science classes, improves student achievement (Balta, 2016), enhances learning outcomes and student activities (Marfilinda et al., 2020), and more successfully reduces misconceptions and increases conceptual understanding in students than other learning methods (Mekonnen et al., 2024). The primary goal of the 7E learning cycle is to highlight how crucial it is to extract existing knowledge and apply those ideas in a fresh setting (Balta, 2016). This methodology aims to enhance students' conceptual comprehension of kinematics topics through the use of concept cartoons.

In order to identify students' misconceptions about certain science topics and to develop suitable interventions to address them where possible, concept cartoons have become an increasingly popular innovative teaching method (Kumi-Manu, 2021). In a classroom context, concept cartoons can help students organise their cognitive structures, confront their knowledge, and explore ideas. They can also successfully depict complex and abstract themes (Ozdemir, 2022). (Yilmaz, 2020). According to earlier studies, concept cartoons can help students better understand physics concepts and dispel common misconceptions about things like force and motion (Ozdemir, 2022), electricity (Siong et al., 2023), and astronomy (Çetinkaya et al., 2022; Türkoğlu & Serttaş, 2020). Taşlıdere's study from 2021 revealed that using concept cartoons in conjunction with the 5E learning cycle learning model improved students' conceptual grasp of waves and decreased their level of misperception. According to other research, concept cartoons incorporated into worksheets can improve students' conceptual grasp of Newton's Law of Motion and help them replace their alternative ideas with scientific ideas (Atasoy & Ergin, 2017).

According to the previous studies, the use of concept cartoons with constructivist learning model and worksheets is reported to help students understand science concepts more effectively and can also eliminate misconceptions. However, there is limited research examining how students' conceptual understanding is affected when concept cartoons are combined with worksheets and constructivist learning model in kinematics topic. Therefore, this study aims to determine the effectiveness of using concept cartoons embedded in student worksheets based on 7E learning cycle phases to improve students' conceptual understanding of kinematics. In this study, researcher developed concept cartoons focused on misconceptions that are still widely experienced by students on kinematics from the findings of research that has been conducted by Estacio et al. (2024), Gumay (2021), Khoirunnisa et al. (2024), Rohmah et al. (2019), and Syuhendri (2019). The misconceptions highlighted in the concept cartoons in this study include: 1) distance and displacement are calculated using the same mathematical equation, 2) instantaneous/average velocity equals instantaneous/average speed, 3) heavier objects fall faster, 4) the acceleration of an upward moving object at the highest point is equal to zero, and 5) gravity increases as objects fall.

METHOD

Research Design and Procedures

This research used a quasi-experimental method using a pretest-posttest control group design, which is research by examining the difference in achievement between the experimental group and the achievement of the control group (Creswell, 2009). In the initial stage of the research, a pretest was carried out on the experimental group and control group to obtain initial data on students' conceptual understanding of the concept of kinematics. After that, learning was carried out over three meetings. The experimental group was treated with the application of integrated cartoon concepts in student worksheets based on the stages of the 7E learning cycle learning model. Meanwhile, the control group only uses structured worksheets based on the 7E learning cycle learning model. The 7E learning cycle model consisting of the elicit, engage, explore, explain, elaborate, evaluate, and extend phases. After all the learning has been carried out, a posttest is given to both classes to obtain final data on students' conceptual understanding.

Population and Sample

The population in this study was 284 seventh grade students in one of the public junior high schools in Semarang City which had been divided into 8 classes. The sample in this study was selected using cluster random sampling technique. This is carried out after taking into consideration certain features, such as the following: it was not possible to perform pure randomization and create a new class for the study; students are taught using the same curriculum; students being studied are seated at the same grade level; and there are no superior classes or class divisions based on ranking. The population of eight classes that have been tested homogeneous were randomly selected to get two classes used as experimental groups and control groups. With this technique, researcher obtained two sample classes, which were class 7F with 36 students consisting of 18 boys and 18 girls as the experimental group and class 7G with 34 students consisting of 17 boys and 17 girls as the control group.

Data Collection and Instrument

The test method is used to determine the achievement of students' conceptual understanding on the kinematic concepts. Students' conceptual understanding was measured using a test instrument in the form of multiple-choice objective tests with explanations. A total of 12 questions were developed covering three aspects of Bloom's cognitive domain, including understanding (C2), application (C3), and analysis (C4). The instrument has been tested on 30 students, with the results meeting the validity of the construct and contents, and obtained a reliability coefficient of 0.79, which means the consistency level is good, so this test instrument is reliable for its use. The test was given to the sample as a pre-test and post-test to obtain initial data and final data on the achievement of students' conceptual understanding on the kinematic concepts. The effectiveness of the intervention was analysed using pretest and posttest data results. The comparison of the two groups may indicate which intervention can significantly improve students' conceptual understanding (Taşlıdere, 2021).

Learning tools including lesson plans, concept cartoons, and worksheets were developed by researcher and validated by two lecturers with expertise in physics education. The recommended revisions were implemented in response to their feedback. The kinematics topic in this study includes three sub-topics, which are quantities in motion, uniform straight motion, and uniformly accelerated linear motion.

Data Analysis

The effectiveness of increasing students' conceptual understanding after receiving treatment was calculated using the normalised average gain formula (n-gain) proposed by Hake (1998). N-gain $\langle g \rangle$ is a rough measure/estimate of the effectiveness of a treatment/learning/lecture in promoting conceptual understanding (Hake, 1998), that can

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be calculated from the ratio of the actual average gain $\langle G \rangle$ and the maximum average gain $\langle G \rangle_{\max}$.

$$\langle g \rangle = \frac{\%\langle G \rangle}{\%\langle G \rangle_{\max}} = \frac{\%\langle S_{post} \rangle - \%\langle S_{pre} \rangle}{100\,\% - \%\langle S_{pre} \rangle}$$

where $\langle S_{pre} \rangle$ is the average score of the pre-test and $\langle S_{post} \rangle$ is the average score of the post-test, with the criteria for the gain factor $\langle g \rangle$ in the Table 1.

Table 1. N-gain Criteria (Hake, 1998)

Criteria	N-gain score
High	$\langle g \rangle > 0{,}7$
Medium	$0{,}3 \geq \langle g \rangle \leq 0{,}7$
Low	$\langle g \rangle < 0{,}3$

Then, using the independent sample t-test, a hypothesis test was run on the actual gain data of the two groups to ascertain the significance of the difference in the enhancement of conceptual comprehension between the experimental group and the control group. Creswell (2009) states that one statistical technique used to ascertain whether there is a significant difference between the means of two independent groups is the independent sample t-test. After confirming that the data were homogeneous and normally distributed, this t-test was selected. A judgement is made by the researcher by comparing the computed t-statistic to the 95% significance level critical value (p-value). The means of the two groups may differ considerably if the t-test result is significant ($p\text{-value} < 0.05$). A non-significant t-test result ($p\text{-value} \geq 0.05$) implies that any observed variation in means may be the product of chance.

RESULT AND DISCUSSION

Based on data analysis of the research results, the average of students' conceptual understanding has increased from the initial state to the final state after being treated in both experimental and control classes. The average scores of pre-test, post-test, and actual gain in students' conceptual understanding on kinematic concepts in the experimental group and the control group can be seen in Figure 2.

The pre-test results, which showed that the experimental group's conceptual understanding was 25% and the control group's was 26%, provide insight into the initial stage of students' conceptual understanding. The post-test results, which showed that the experimental group's conceptual comprehension was 60% and the control group's was 38%, can be used to determine the final state of conceptual understanding following treatment. The experimental group's actual gain value was 34.5%, but the control group's was just 12%. The normalised gain test was then performed for both groups, and the findings revealed that the experimental group had increased conceptual knowledge by 0.45, placing them in the medium category, while the control group had increased conceptual understanding by 0.13, placing them in the low category. This normalised gain value shows that the average increase in conceptual understanding of kinematic concepts in the experimental group is greater than in the control group.

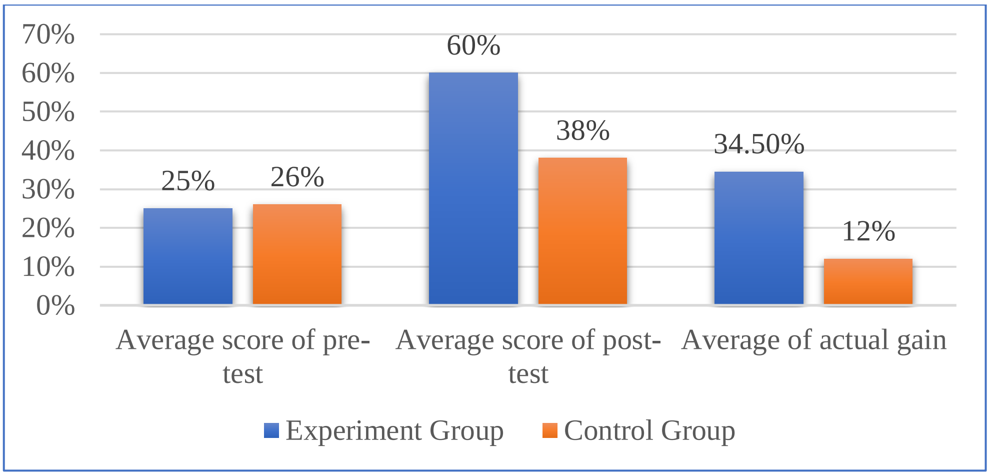

Figure 2. Comparison of gain of the experimental group and control group

To ascertain whether the experimental group's growth in concept knowledge was substantially different from the control group, the normalised gain value derived from the two groups was subsequently tested for significance. Table 2 presents the results of the independent sample t-test that was performed using the IBS SPSS statistics version 21 application.

Table 2. Independent sample t-tests results

		t-test for Equality of Means						
		t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
							Lower	**Upper**
Gain	Equal variances assumed	4.843	68	.000	.312	.0645	.184	.441
	Equal variances not assumed	4.831	66.518	.000	.312	.0647	.183	.442

It is evident from Table 2's t-test results that there is a significant difference between the experimental and control groups' gains in conceptual knowledge. This led to a significant increase in the average conceptual comprehension of the kinematics concept among students in the experimental group as compared to the control group. The findings of this study are in line with earlier research (Atasoy & Ergin, 2017; Atchia & Gunowa, 2024), which suggested that using concept cartoons modified for the constructivist learning paradigm can enhance students' conceptual grasp of the subject.

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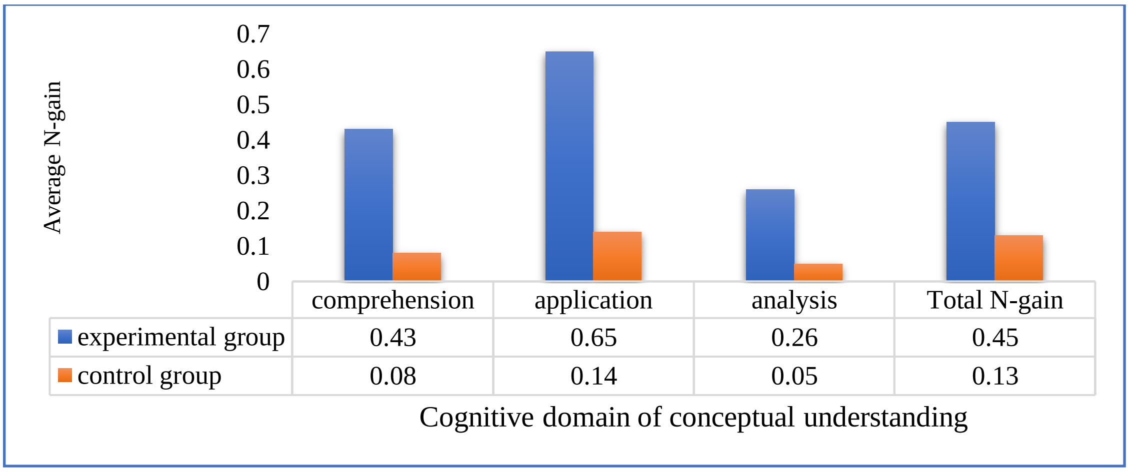

Figure 3. Average n-gain for each cognitive domain of conceptual understanding

The difference in the improvement of students' concept understanding can also be seen from the difference in the improvement of each aspect of Bloom's cognitive domain studied, as shown in Figure 3. Based on the diagram, it can be seen the difference in improvement in each aspect of Bloom's cognitive domain between the experimental class and the control class. The difference in improvement in each aspect of Bloom's cognitive domain, namely, aspects of understanding (C2) by 35%, aspects of application (C3) by 51%, aspects of analysis by 21%.

The highest difference in improvement is in the application aspect. This shows that the use of concept cartoons has more effect on students' cognitive in the application domain. By using concept cartoons as learning media, students become easier to apply their knowledge to everyday problems. The lowest difference in improvement is in the analysis aspect. In this aspect the amount of normalised gain of both classes is equally in the low category. This shows that the use of concept cartoons does not really affect students' cognitive in the analysis domain. Furthermore, the low performance of seventh graders in this area can also be explained by the fact that they are still in the process of moving from concrete to abstract thought, which makes it harder for them to solve analytical problems.

In general, students' conceptual understanding has increased in both experimental and control classes. This can be due to the fact that the two classes both implemented learning with the 7E learning cycle model assisted by student worksheets, where the 7E learning cycle has been proven to enhance students' learning outcomes (Marfilinda et al., 2020; Mekonnen et al., 2024). There was a significant difference in improvement between the experimental class and the control class because the two classes received different treatments, which is only in the experimental class which was given treatment in the form of concept cartoons. The results of this study indicate that the use of concept cartoons integrated with worksheet can further improve junior high school students' concept understanding of kinematics concepts compared to worksheets that do not use concept cartoons in each cognitive domain studied. According to the research findings, students benefited much from the concept cartoon activities and they also expressed a positive view about the usage of cartoon activities in the classroom. Concept cartoons could be used to guide the questions to be used in concept cartoon activities that use the question-and-answer approach, as compared with the teacher or students doing it directly. This is also supported by the results of the research of Akbaş & Kılıç (2019), which indicated that the concept cartoon exercises utilised in the study had colourful illustrations, intriguing character names, and activities that catered to the cognitive abilities of the students.

In this research, concept cartoons are designed to be embedded in student worksheets. To effectively manage the learning time and ensure the clarity of activities in each stage of learning, the concept cartoons worksheet was then adjusted to the phases of the 7E learning cycle model. Concept cartoons are given in the elicit, engage, explore, explain, and elaborate phases. Researcher developed concept cartoons following the guidelines of the development steps by Keogh & Naylor (1999). The concept cartoons emphasizes context-based learning science in everyday life to make unfamiliar scientific knowledge familiar to students. After reviewing related misconceptions in the literature, various alternative ideas/concepts related to kinematics are presented to create cognitive conflict. The arguments presented by each character in the concept cartoon are made concise and clear, so that the cartoon concept can involve students in finding scientific problems and/or problem solving strategies.

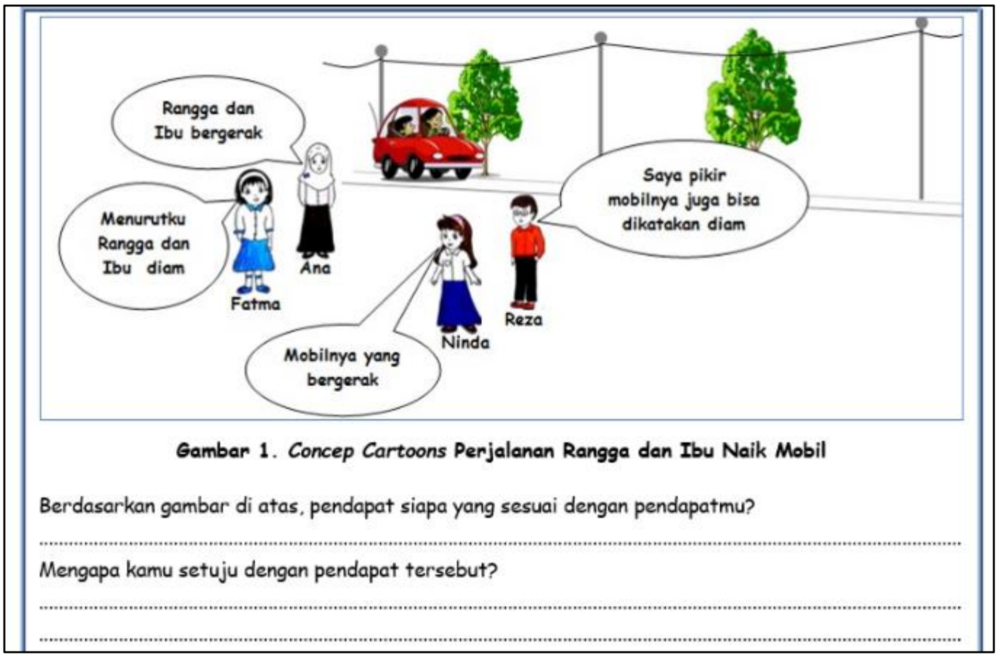

Figure 4. Concept cartoons in elicit phase

Concept cartoons are used in the elicit phase to check students' prior knowledge and direct their attention to the topic matter (Balta, 2016). The teacher will assess any misconceptions students may have and verify the students' initial knowledge. Example of a cartoon concept developed by the researcher and used in this phase is shown in Figure 4. Concept cartoons present an illustration of a phenomenon with several cartoon characters expressing different opinions about the phenomenon (Keogh & Naylor, 1999). In the elicit phase, students are given concept cartoons in order to generate responses from students' ideas and raise curiosity about which opinion is the most appropriate from several opinions of the concept cartoons characters displayed. As found by Ozdemir

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(2022), the use of cartoon concepts in the elicit phase can lead to cognitive conflict, in which the concept of cartoons depicting everyday life situations related to the concept of kinematics can cause or stimulate misconceptions on the concept that are not expressed, thus causing cognitive conflict in students.

During the engage phase, concept cartoons helped to deepen the students' curiosity and past knowledge. Researchers employed concept cartoons to spark conversation in this phase, during which teachers and students shared their knowledge and experiences regarding the original ideas behind the concept cartoons from the elicit phase. As seen in Figure 5, concepts from the concept cartoon offer insightful information about the conceptions or ideas of the students. Additionally, the tool invites students to share their thoughts, which could lead the teacher to identify any misconceptions the students may have (Estacio et al., 2024). The students have the chance to contrast their original concepts with those in the cartoons during class and group discussions. This gives them a chance to share their opinions and have a discussion (Türkoğlu & Serttaş, 2020). Students can have group discussions on concepts in the classroom when concept cartoons are used. They can evaluate their cognitive state and make any necessary revisions in light of these conversations and points of view (Inan & Kaya, 2017). They expanded on their original conceptual frameworks and heard their colleagues clarify the correct science concepts. This enabled the students to use concept cartoon-based learning in an interactive setting to clear up any misunderstandings they may have had (Kumi-Manu, 2021). During the investigate phase, students will be motivated to conduct concept exploration activities by their interest regarding the best opinion.

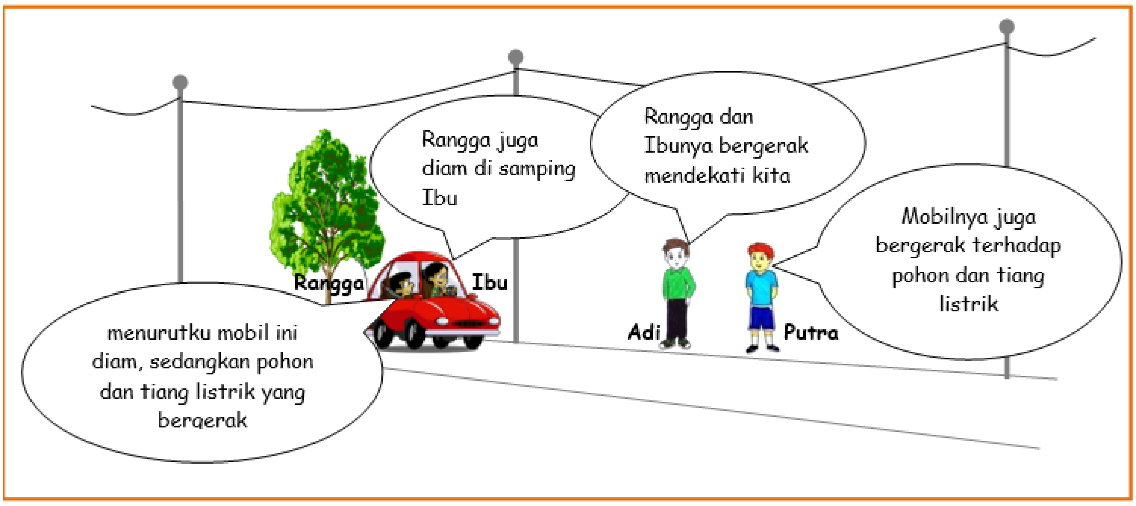

Figure 5. Concept cartoons in engage phase

The teacher gives students time to get answers to their initial guesses about the concepts they learned in the explore phase. Activities in this phase aim to provide knowledge to students with direct experience where students can observe, ask questions or investigate concepts from materials that have been provided previously (Mekonnen et al., 2024). In the explore phase, students actively participate in activities to gain their own knowledge. Student activeness in the explore phase is highly emphasised by researcher, this condition is in line with the finding of Atasoy and Ergin (2017) which indicates that teaching success is determined not only by the concept cartoons themselves, but also by the quality of classroom interactions during debate and inquiry of the phenomena provided through concept cartoons.

The explore phase in this study was filled with experimental activities, direct observation of a phenomenon, literature study of textbooks and other learning materials, and asking the teacher. In this study, experimental activities on the topic of uniform straight motion and uniformly accelerated linear motion could not be carried out as designed in the study due to the limited facilities available. The experimental activities were then replaced with literature study activities and demonstrations using learning media by the teacher. After conducting exploration activities, students are directed to discuss and explain the initial concepts they have obtained (explain phase).

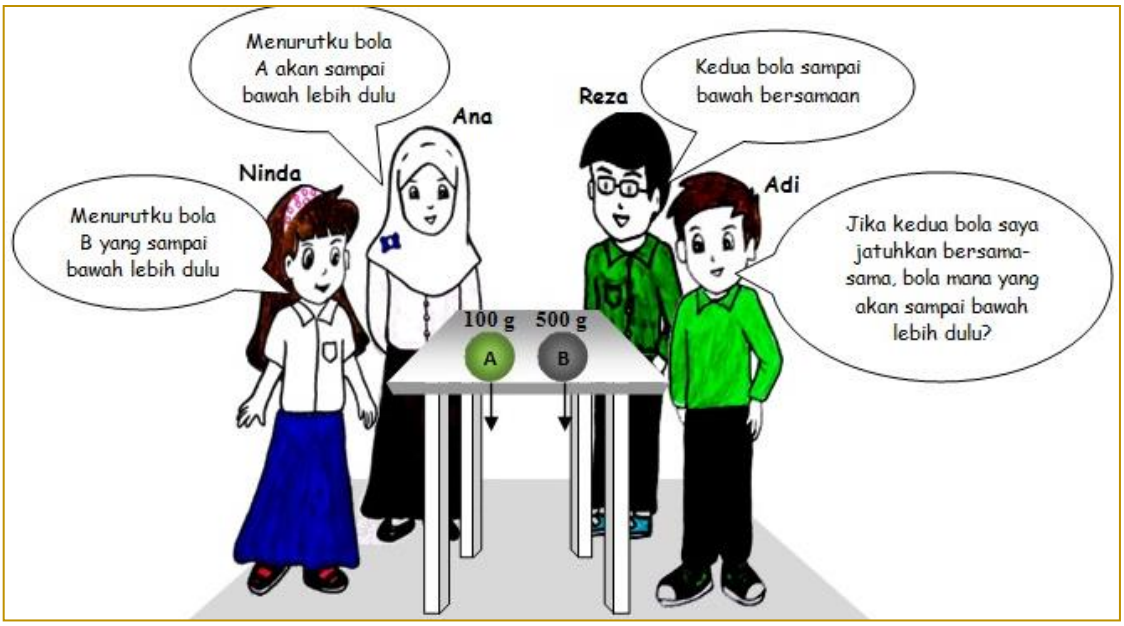

Figure 6. Concept cartoons in explore phase

Before the experiment in explore phase, students in the experimental group were given a concept cartoon drawing in Figure 6. Based on classroom observations, many students agreed with Ninda's opinion, where ball B will reach the bottom first compared to ball A which has a smaller mass. This is in line with the misconceptions found in the research conducted by Estacio et al. (2024), Gumay (2021), Syuhendri (2019), and Sulistri & Lisdawati (2017) that when two objects are dropped from the same height but have different masses, the object with the heavier mass will hit the ground first and fall through time more quickly than the object with the lighter mass. After conducting the experiment and students were asked to discuss again related to the concept cartoon in Figure 7, there was a change in answers by students. Most students agree more with Reza's view, which states that ball A and ball B will reach the bottom simultaneously.

This result is consistent with earlier study (Siong et al., 2023; Taşlıdere, 2021), which suggests that conceptual knowledge may be enhanced and misconceptions could be eliminated by conceptual change-oriented training utilising concept cartoon worksheets. Additionally, Atasoy and Ergin's (2017) research shown that concept cartoon-integrated worksheets improved students' conceptual comprehension by replacing misconceptions with scientific ideas.

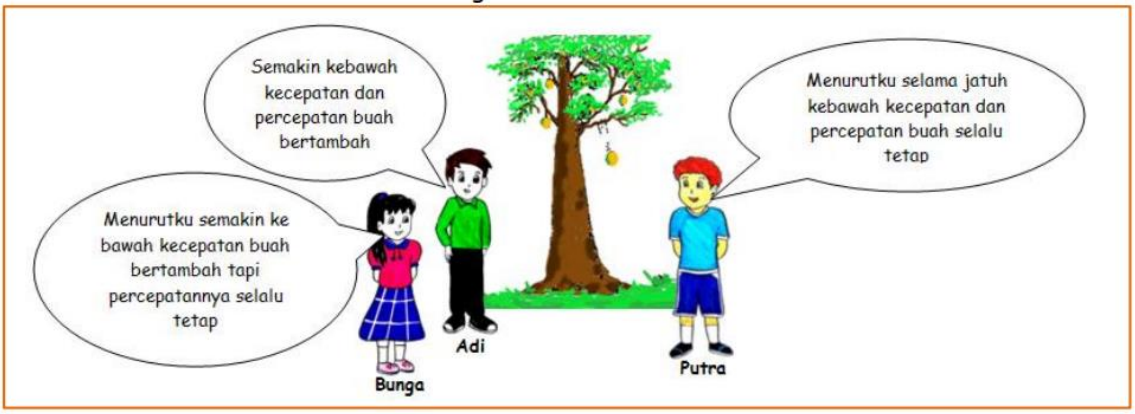

Figure 7. Concept cartoons in explain phase

In the explain phase, the teacher's role as a facilitator is highly emphasised to be able to direct the discussion so that in the end it leads to the conclusion of scientific conception with a more formal definition. Concept cartoons consistently grab students' attention during everyday lessons and promote peer debate and discussion as shown in Figure 7. Teachers might monitor their students' comprehension and thinking processes by using concept cartoons to prevent misconceptions (Yin et al., 2016). The teacher guides students to update or reconstruct their initial conceptions to be adjusted to the scientific conceptions they have gained based on experience and direct observation in the explore phase. Deep mastery of concepts by the teacher is very necessary, because in this phase the teacher must be able to direct students' various conceptions towards one scientific conception. If the teacher does not master the concept of the material correctly, students may experience misconceptions about the material being studied. The concept cartoon format encourages discussion and debate among students. This social interaction helps students to articulate their ideas, listen to others, and refine their understanding. It also allows teachers to facilitate the discussion and guide students towards the scientifically accepted view (Kusumaningrum et al., 2018).

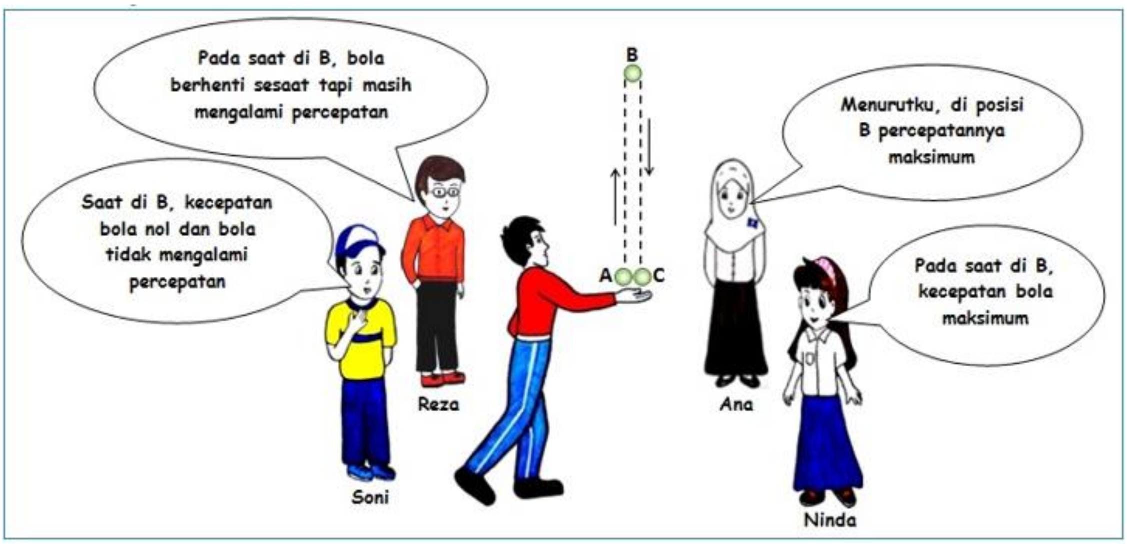

Figure 8. Concept cartoons in elaborate phase

Students are trained to apply the concepts they have obtained in the elaborate phase. In this phase, the researcher uses concept cartoons that display problems related to the concepts learned to train students' skills in applying the concepts they have just acquired, as depicted in Figure 8. When students are involved with concept cartoons, they seem to experience cognitive conflict when faced with conflicting but seemingly reasonable ideas (Keogh & Naylor, 1999). By presenting multiple views, concept cartoons create cognitive conflict, which is a crucial step in conceptual change. This conflict motivates students to think critically and justify their ideas, leading to a deeper understanding of the topic. After practising applying the concept, students conduct evaluation activities to determine the extent to which the newly learned concepts have been mastered (evaluate phase). The last learning phase is the extend phase. In this phase, researcher used concept cartoons to develop students' critical thinking skills to be able to explain other examples of the application of the concepts they have learned, so that students can expand their concepts and can find relationships between concepts.

When giving concept cartoons in the first lesson, many students considered that more than one opinion of the concept cartoons character was correct. This does not make students afraid to express their opinions, because students are not required to give the correct answer and are free to choose the opinion of the concept cartoons character that best suits their thinking. The use of concept cartoons makes students actively participate and are not afraid to express their answers because students will feel that the answers they give are not their characters, but the characters in concept cartoons that are the same as their thoughts (Atasoy & Ergin, 2017; Kumi-Manu, 2021). During the learning process, students were active in expressing their opinions on the characters they chose and expressed different reasons to support their opinions on the concept cartoons characters they chose. The findings of this study support previous studies (Ozdemir, 2022; Yin et al., 2016), that the use of concept cartoons in learning ensures students actively participate in the classroom by promoting their arguments.

In this study, concept cartoons are rooted in the 7E learning cycle model, which emphasizes the active engagement of learners in the development of their own ideas. This model aligns with the principles of constructivist learning, where learners are encouraged to explore, investigate, and construct their own understanding of concepts through social interactions and peer discussions. Concept cartoons facilitate this process by providing a visual representation of different perspectives, encouraging learners to engage in critical thinking and argumentation (Çetinkaya et al., 2022). Instruction with concept cartoons is effective because it is enjoyable; it instructs while entertaining, encourages students to actively participate in class, and maintains students' attention (Yilmaz, 2020). Concept cartoons give concepts a visual representation, improve students' motivation towards the lesson, engage them in the process, and make learning more fun. Therefore, concept cartoons should be viewed in conjunction with other strategies that seek to provide opportunities for active learning and encourage conceptual development (Keogh & Naylor, 1999).

Based on the results of statistical tests, this study shows that there are significant differences between classes that use concept cartoons integrated into LKS and classes that only use LKS even though both use the 7E learning cycle model. These results have proven that concept cartoons are an effective media used with constructivist learning to improve students' conceptual understanding. However, the gain in students' conceptual understanding in both classes still shows moderate and low categories, where in both classes there are still misconceptions experienced by students on the concept of kinematics after learning. Therefore, in further research it is necessary to emphasize the implementation of activities in each phase of learning of the 7E cycle. In addition, the availability of tools that support the activities of students in the explore phase should be noted, because the lack of tools can interfere with students' exploration activities to acquire knowledge. Further research is needed to find out the effectiveness of using concept cartoons in other learning models and other topics.

CONCLUSION

The effectiveness of using cartoon concepts to improve students' conceptual understanding of kinematics concepts in both groups can be seen from the normalised gain value. Where in the experimental group there was an increase of 0.45 (medium category), which was higher than the increase in students' concept understanding in the control group with a normalised gain of 0.13 (low category). Based on the results of statistical tests in this study, it was found that there was a statistically significant difference between the group treated using concept cartoons and the group without the intervention of concept cartoons in improving students' conceptual understanding of kinematic concepts. The results showed that students who were taught with concept cartoons worksheets based on 7E learning cycle model had their conceptual understanding significantly improved compared to students in the control group.

This study also found that concept cartoons are useful tools for detecting misconceptions. The use of concept cartoons before instruction can provoke understandings, which in turn lead to learning activities and make students active in learning by increasing their motivation to discuss and question their and others' understandings. Students were also observed to have experienced conceptual changes, from initial misconceptions to correct concepts before and after exploration activities. However, the results of observations during this research process show that qualified teachers to support discussions and learning tools that support exploration and experiment activities are needed to help students find scientifically correct concepts to improve their conceptual understanding.

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