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Development of HOTS Kinematics Questions with Daily Activities

Tutik Suyani[1], Jeffry Handhika[2*], Mislan Sasono[3]

[1,2,3]Universitas PGRI Madiun, Indonesia

**Corresponding Address:* jhandhika@unipma.ac.id

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ABSTRACT

The ability to think critically and creatively can be the strongest foundation of science. They can be developed by answering HOTS questions. This research aims to develop HOTS Kinematics questions with daily activities. This research employed the 4D model. The CVI value was 0.998, based on content validity, construct, and language validation results. The product trials were held twice to see the consistency of the test results. The first and second product trial results found that 12 questions were valid, with reliability in the first product trial of 0.694 and the second product trial of 0.977. In addition to the validity and reliability tests, the discriminating power test and the difficulty level test were also carried out. The result of the analysis of the research product is that 12 of 30 questions developed were suitable for use, marked by the value of test item validity, reliability, difficulty level test, and discriminating power test, which were consistent with the first and second product trials. The questions were developed to have indicators of critical and creative thinking. Of twelve valid questions, seven are questions with creative thinking indicators, and five items with critical thinking indicators. The product of this development can be used as an instrument to improve critical and creative thinking skills.

INTRODUCTION

The ability to think critically means that a person will have the ability to observe, analyze, reason, judge, make decisions, and persuade well (Dwyer et al., 2014; Ennis, 1991; Zuriguel-Pérez et al., 2019). The more advanced the critical thinking skills, the more advanced the problem-solving capability (Hardika, 2020). Critical thinking skills seem to determine high achievement in science because they can guide thinking and take action based on intellectual values (Espinosa et al., 2013). This statement supports the opinion that critical thinking skills are needed in science learning activities because learning science requires advanced thinking (Wahyuni, 2015). The ability to think creatively means generating new ideas, designing new solutions, thinking uniquely and differently, being original, and communicating well (Mahanal & Siti Zubaidah, 2017). Critical thinking skills are classified as essential and have acted in entire aspects of life (Prameswari et al., 2018). Previous studies have shown that student achievement is affected by critical thinking and creative thinking skills (Karagöl & Bekmezci, 2015). Yazar (2015) said that creative thinking skills are related to critical thinking skills. To think creatively you must have critical thinking, and vice versa. Critical and creative thinking build and complement each other. The capability to think creatively and critically belongs to the Higher-Order Thinking Skills (HOTS), and the quality of physics learning is influenced by HOTS (J.L.S. et al., 2018).

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The current curriculum in the educational process emphasizes competence in Higher-Order Thinking Skills (HOTS) (Ariyana et al., 2018) with scientific access, including observing, inquisitive, filtering, displaying, concluding, and creating (Sari, 2015). Based on observations made by (Chania et al., 2020), teaching materials do not support or refer to the HOTS questions. Students graduated with low critical thinking skills predicates (Carlgren, 2013; Irwanto et al., 2021).

In a survey conducted by (Malik et al., 2018), 50% of physics teachers tend to use Lower-Order Thinking Skills (LOTS) when compiling items, and 75% measure memory skills. The 2018 Program for International Student Assessment (PISA) supports this fact, which affirms that in science, Indonesia is ranked 70th among 78 countries (OECD, 2019). Most Indonesian students are still at the LOTS (Nugroho, 2018). One of the chapters that has a lot of HOTS questions and confuses students is Kinematics. In this chapter, students find difficulties because they are still in the LOTS stage but are forced to work on HOTS questions.

Students' understanding of physics concepts in the good category is 21.67%, and many errors occur when analyzing kinematics material (Pujianto, 2013). Therefore, they must have many sources of Kinematics HOTS questions to study. The first step to composing the HOTS questions, according to Ariyana et al. (2018), is to make the HOTS questions an interesting and contextual stimulus. Also, Ardiansyah et al. (2019) said that we need contextual value to understand good physics concepts. Contextual is learning by relating the material to the student's environment and encouraging them to use it in everyday life (Kadir, 2013).

The results of teacher interviews in high schools where this research was conducted include that the students found it difficult to work on Kinematics Physics questions after learning. A few students only possessed physics scores above the minimum completeness criteria. Most of the exam questions were HOTS-based. They are rarely or never given physics questions that contain the environment around them as a form of application of physics problems. The explanation above shows students need the HOTS-Oriented evaluation practice to work on contextual HOTS questions. The contextual value of the questions can be related to the environment around them. This research aimed to develop HOTS Kinematics questions with daily activity contents.

Previous research by Maxnun et al. (2024) developed village-based HOTS questions using the ADDIE method and had gone through readability tests. Dewi & Kuswanto (2023) developed questions using the 4D method and were tested for validation and product trials. The difference between the HOTS questions developed in this research and the HOTS questions, in general, is that the HOTS questions developed contain students' daily activities at the Madiun Residency Square, which in this study is referred to as the daily activity. In addition, the questions developed are focused on combining critical and creative thinking questions at the C4 and C5 levels (Lorin & Longman, 2001). The purpose of this research is to develop HOTS kinematics questions with a daily activity suitable for use in the student assessment process with the hope of improving students' critical and creative thinking skills.

METHODS

This research adopts the Research & Development (R & D) method with the 4D research model (Define, Design, Development, and Disseminate) (Sugiyono., 2018). This research was conducted from January to May 2022 in the Madiun Residency. The Define stage is the process of analyzing various literature studies regarding the needs and problems in the world of education, observing the high school students who are research samples, and formulating instructional objectives. The Design stage is made by arranging instrument standards,

specifications, and product prototypes. The Develop stage is done by assessing the product by the experts and performing product trials. The assessments test the value of the content, construct, and Language. The Education Assessment Team (2019) uses the standard to test the values. Five validators were involved in the content and construct validation. Specifically, three validators are supervisors for high school students Olympic in Madiun, and two validators are high school teachers in Madiun. The product from the expert assessment was measured by CVR and CVI analysis by Lawshe (Persista et al., 2021).

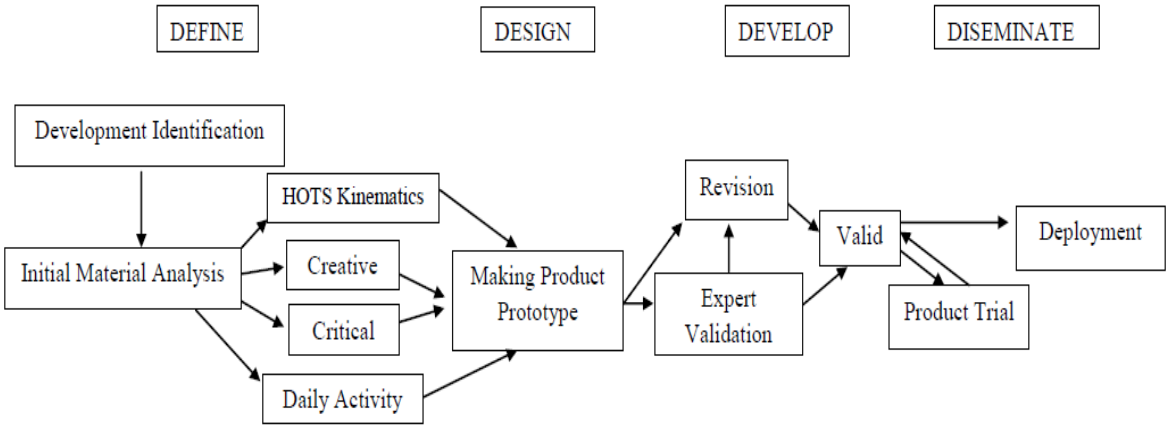


Figure 1. Development Stages

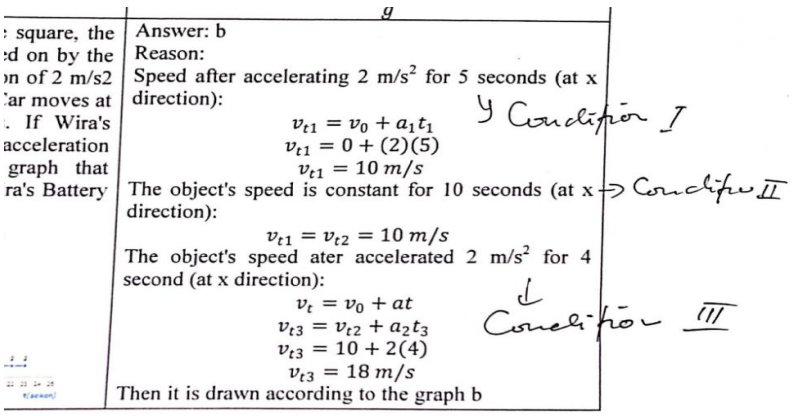
The product trials were conducted twice on 55 senior high school students. The item validity test was calculated using biserial point analysis. The reliability test was calculated using the Guttman Split-Half coefficient. The difficulty level was tested by looking for the difficulty index value. The discriminating power test was carried out by calculating the discrimination index. The first trial was conducted to select questions that could not be used in the assessment. The selection was made based on item validity and reliability, discriminating power, and level of difficulty test. The second product trial was conducted to see whether the questions that passed the first product trial would have consistent results. The final stage in the 4D development is Disseminate. The dissemination process is the dissemination of questions that have been valid and suitable for use.

RESULTS AND DISCUSSION

The output of this research is 12 valid kinematics HOTS questions. Seven out of twelve are HOTS questions with creative thinking indicators, and five are with critical thinking indicators. These 12 Valid Questions have been through peer testing, expert assessment, and product validity testing twice (with analysis of item validity, reliability, level of difficulty, and discriminating power).

A total of 30 items had been validated after going through peer and expert validity tests (Content and Construct). The content and construct validity test was tested using the CVR and CVI equations proposed by Lawshe (Persista et al., 2021).

The content, construct, and language assessment results by experts had an average CVR value of 98.96% and a CVI of 0.989 (excellent category). Content CVI value is 0.98, Construct is 0.98, and Language is 1. From the results of expert validation, several parts of the questions received feedback, and experts suggested revisions. The feedback received was evaluated in a formative manner (Bakri et al., 2018). Furthermore, the questions were revised according to the evaluation results. The experts' suggested revisions can be seen in Figures 2 to Figure 8.



square, the
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ar moves at
. If Wira's
acceleration
graph that
ra's Battery

Answer: b
Reason:
Speed after accelerating 2 m/s^2 for 5 seconds (at x direction):

$$v_{t1} = v_0 + a_1 t_1$$
$$v_{t1} = 0 + (2)(5)$$
$$v_{t1} = 10\ m/s$$

The object's speed is constant for 10 seconds (at x direction):

$$v_{t1} = v_{t2} = 10\ m/s$$

The object's speed ater accelerated 2 m/s^2 for 4 second (at x direction):

$$v_t = v_0 + at$$
$$v_{t3} = v_{t2} + a_2 t_3$$
$$v_{t3} = 10 + 2(4)$$
$$v_{t3} = 18\ m/s$$

Then it is drawn according to the graph b

Figure 2. The Revision of Conditions

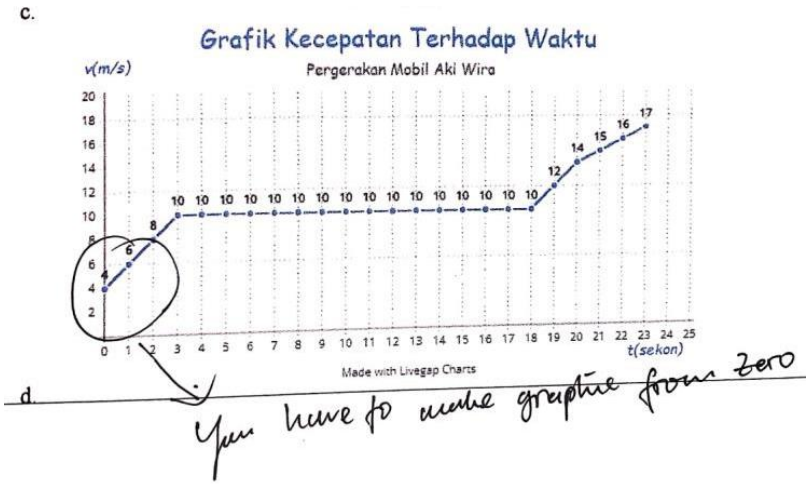


Figure 3. The Revision of Graphics

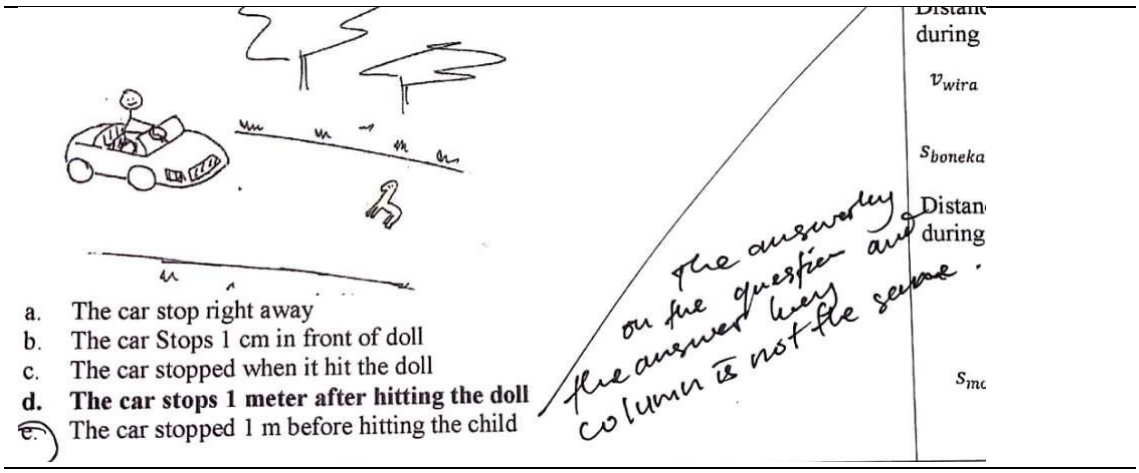


Figure 4. The Revision of Answer Key Options

(Validate)	Creative (Make deductions and judge deductions) Analyzing Argument

Figure 5. The Revision of Indicators

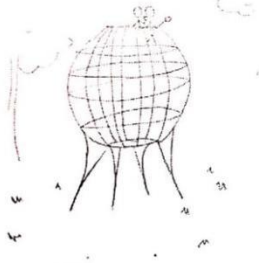
4. Ana and Ani are playing in the Alun-Alun, both of them buy rubber balls of different colors. Ani's ball is green, and Ana's is red. Ani throws the green ball vertically upwards with a speed of 1 second, Ana throws the red ball vertically upwards with speed. The height that Ana's ball reaches when it meets Ani's ball is....
   a. 3,0 m
   b. 4,8 m
   c. 5,2 m
   d. 5,8 m
   e. 6,8 m

↓ you have to create add description of simi cenky of place

Figure 6. The Revision of Description

16. Wira is riding a battery car in the square, the car is initially silent and th by the Wira and moves with an acceleration of 2 m/s^2 for 5 seconds. Battery Car moves at a constant speed for 15 seconds. If Wira's Ba accelerated with an speed of 2 m/s^2 for 4 seconds, the graph that corres movement of Wira's Battery Car is....

Figure 7. The Revision of Writing Errors



→ the picture was not clear

a. 100 cm
b. 120 cm
c. 150 cm
d. 180 cm

Figure 8. The Revision of Clarity of Illustration

Figure 2 shows that providing information regarding the conditions of events explained mathematically was necessary. This revision was required because, in question number 16, the answer key contained only a mathematical analysis without explaining what the analysis showed. Therefore, information on this incident needed to be clarified. In Figure 3, the graph revision must be done by changing the starting point from zero because some graphs start not from zero. In answer options, graphs A and B start from zero, while in options C, D, and E, the graphs start from number two. To avoid confusing students, the experts suggested revising and changing the graph from number 2 to zero. Figure 4 shows the errors contained in the answer key. Mathematically, the answer key was appropriate and correct; there were errors in the options. Question number 18's answer key was D with narration from option E. There needed to be a revision to change the answer key narrative according to the question options.

In Figure 5, it was necessary to change the indicators from “making deductions” and “assessing the deductions" to “analyze arguments.” Figure 6 shows a note from the expert that the question requires a description. Therefore, it was revised by adding the information. This revision was carried out on number 28. It was feared that if students were not given the information, they would misunderstand the events described by the questions. Figure 7 shows a spelling error in the numbers and unit values. They were written in acceleration, but the speed was written in the description. To prevent confusion and harmonize the situation, it was necessary to have a revision. In Figure 8, there is a note from the expert that the image used was unclear. After the questions were revised, the first product trial started. Product trials aim to determine the effectiveness of the questions (Liana et al., 2020).

Twenty-six high school students in Madiun attended the first product trial. Before the product trial was done, the students were given instructions about three days before the product trial. The students were given information that there would be a product development test. They were given instructions to re-learn the Kinematics material so ready themselves.

The validity test was performed using biserial point analysis. The results found that 12 items were valid and 18 questions were invalid. After testing the validity of the items, the reliability test was carried out using the Guttman Split-Half Coefficient test (Sugiyono., 2018). Based on the reliability test results, the coefficient was 0.694, and the r table 5% was 0.388 for 26 respondents. The questions were declared reliable because the value of r (Guttman Split-Half coefficient) was greater than the r table (Janna & Herianto, 2021). After going through the validity and reliability tests, the difficulty level and discriminating power were tested. The test results can be seen in Tables 3 and 4.

Table 1. Validity of Items

	Question Number	Total	Number of Creative thinking questions	Number of critical thinking questions
Valid	3,6,13,14,15,16,18,23,24 ,26,27,28	12	7	5
Not Valid	1,2,4,5,7,8,9,10,11,12,17 ,19,20,21,22,25,29,30	18	8	10

Table 2. Reliability

Cronbach's Alpha	Value	0, 631
	N of Items	6[a]
	Value	-0,043[b]
	N of Items	6[c]
	Total N of Items	12
Correlation Between Forms		0,609
Spearman-Brown Coefficient	Equal Length	0,757
	Unequal Length	0,757
Guttman Split-Half Coefficient	30	0,694

Table 3. Interpretation of Difficulty Level

P value	Interpretation	No. Valid Question	No. Invalid Question	Total number
Less than 0.30	Too Difficult	3,6,14,16,23,24, 26,28	2,4,5,10,12,19, 22,25,29	17
0,3-0,70	Moderate	13,15,27	1,7,8,11,21	8
More than 0.70	Too easy	18	9,17,20,30	5

The discriminatory power test was carried out by finding the value of the discriminatory power index. If the value of the discriminating index is negative, then the question has poor discriminatory power. If it is less than 0.20, the value has a bad discriminant power. If the discriminant value is between 0.20 and 0.40, then it has a moderate discriminating power. The question has good distinguishing power if the discriminant value is between 0.40 and 0.70. Finally, if the discriminant value is between 0.70 and 1.00, the question has excellent discriminating power (Magdalena et al., 2021). Table 4 shows that six questions have bad discriminating power, 14 have poor discriminating power, ten have moderate discriminating power, and two have good discriminating power. Based on the interpretation of the discriminating power, 12 valid questions have a moderate discriminating power of 58%, while the remaining 42% do not have adequate discriminating power.

Table 4. Interpretation of Discriminating Power

D	Interpretation	No. Valid Question	No. Invalid Question	Total number
Less than 0.20	Poor	3, 23, 6	1, 2,4,5, 9,10,12,20,22, 29, 30	14
0,20-0,40	Moderate	13, 14, 15, 16, 24	8, 11,21	10
0,40-0,70	Good	18, 27	-	2
0,70-1,00	Excellent	-	-	-
Signed negative	Poor	26, 28	7,17,19,25	6

The first product trial resulted in 12 valid questions out of 30. One cause of invalid questions was that they were too difficult, indicated by the level of difficulty test (17 out of 30 items are too difficult). The questions that could not be answered correctly caused their validity to be undefined in the SPSS (Appendix 4). Therefore, the next step was eliminating the invalid questions. After the questions had been eliminated, the next 12 valid questions went through the second product trial stage.

The second product trial was performed to determine whether the questions developed were valid and feasible. The purpose of the second product trial was to see the consistency of the validity of the questions developed. The results of the second product

trial were analyzed with the same test as the first, namely the validity, reliability, level of difficulty, and discriminating power analysis. The second product trial was conducted on 29 high school/equivalent students. The questions tested were 12 valid items. The questions in the second product trial were declared valid and consistent. After performing the validity of the questions, then the reliability test was carried out. Based on the product reliability test, the reliability coefficient was 0.977, and the r table 5% was 0.367 for 29 respondents. The questions were declared reliable because the value of r (Guttman Split-Half coefficient) was greater than the r table. After going through the validity and reliability tests, the second product trial was continued with the level of difficulty and discriminating power test. The test results can be seen in Tables 5 and 6.

Table 5. The Reliability of the Second Product Trial

Cronbach's Alpha	Value	0,707
	N of Items	6[a]
	Value	0,763
	N of Items	6[b]
	Total N of Items	12
Correlation Between Forms		0,958
Spearman-BrownCoefficient	Equal Length	0,979
	Unequal Length	0,979
Guttman Split-Half Coefficient	30	0,977

Table 6. The Interpretation of the Difficulty Level in the Second Product Trial

P value	Interpretation	No. Question	Total number
Less than 0.30	Too Difficult	2,4,5,6,8,10,11	7
0,3-0,70	Moderate (Medium)	1,3,7,9,12	5
More than 0.70	Too easy	0	0

Table 7. The Interpretation of the Discriminating Power in the Second Product Trial

D	Interpretation	No. Question	Total number
Less than 0.20	Poor	0	0
0,20-0,40	Moderate	2,4,11	3
0,40-0,70	Good	3,5,6,8,10,12	6
0,70-1,00	Excellent	1,7,9	3
Signed negative	Poor	0	0

Table 6 reveals that seven items belonged to the difficult category, and five belonged to the moderate category. Table 7 analyzes the discriminating power.

Table 7 shows that three questions were in the moderate discriminating power category, six were in the good discriminating power category, and three were in the excellent discriminating power category. The interpretation of the discriminating power value followed the opinion of (Sudijono, 2009). Thus, the 12 questions were consistent, valid, and reliable. The questions met the requirements of the test questions according to (Sudijono, 2009). These questions can then be used in the assessment process at school or can be used to conduct other related research. The limitation of the research was that not all critical and creative thinking indicators were contained in the questions (All questions developed were included in the HOTS questions) because the questions developed were limited to multiple-choice questions. Therefore, the questions cannot measure all critical and creative thinking aspects.

CONCLUSION AND SUGGESTION

This research was conducted to develop HOTS (Higher-Order Thinking Skill) questions on high school kinematics materials containing daily activities. The development was adjusted to the R&D method with the 4D Model (Define, Design,

Develop, and Disseminate). The content and construct validity test results stated that the product was feasible and very suitable for use in the assessment with a CVI value of 0.989 (Very Appropriate). After performing two trials, there were 12 valid questions; seven were in the creative thinking category, and five were in the critical thinking category. The limitation of the research was that not all critical and creative thinking indicators were contained in the questions (All questions developed were included in the HOTS questions) because the questions developed were limited to multiple-choice questions. Further research can be conducted to develop multiple-choice and description questions so that all critical and creative thinking indicators can be contained in the whole question.

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