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Development of a STEM-Based Kinetrac Teaching Aid to Improve Students' Creative Thinking Skills in Uniformly Accelerated Motion

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Abstract. This study was motivated by the low level of students' creative thinking skills in physics learning, particularly in uniformly accelerated motion (UAM), where students tend to be limited in generating ideas, exploring various approaches, and developing diverse solutions. This study aimed to develop a Kinetrac teaching aid based on the STEM approach and to analyze its feasibility, effectiveness in improving creative thinking skills, and student responses. This study employed a Research and Development (R&D) method using the ADDIE model. The research subjects were grade X students of MA Mujahidin, consisting of an experimental class and a control class. The results showed that the Kinetrac teaching aid achieved a feasibility score of 83.8%, indicating that it is feasible. The effectiveness test indicated a significant difference between the experimental and control groups ($p < 0.05$). Furthermore, the N-Gain score in the experimental class was 52.28% (moderate category), while the control class obtained 29.24% (low category). Students' responses toward the use of the Kinetrac teaching aid were highly positive, with a percentage of 88%. It can be concluded that the STEM-based Kinetrac teaching aid is feasible and effective in improving students' creative thinking skills in physics learning on the UAM material.

Keywords: creative thinking skills, Kinetrac teaching aid, uniformly accelerated motion, physics learning, STEM

INTRODUCTION

The rapid development of science and technology in the era of the Industrial Revolution 4.0 has significantly influenced various aspects of life, including education. The integration of technology in learning plays an essential role in improving the quality of teaching and learning processes, particularly in creating interactive, contextual, and problem-oriented learning environments (Siringoringo & Alfaridzi, 2024). In line with these demands, 21st-century education emphasizes the mastery of essential competencies such as critical thinking, creativity, collaboration, and communication. Among these, creative thinking is a key aspect, as it is closely related to the ability to generate new ideas, explore alternative solutions, and develop original concepts in real-world contexts (Hufri et al., 2022; Suherman et al., 2025).

Despite the importance of technology integration, its implementation in schools remains suboptimal. Physics learning is still predominantly theoretical, teacher-centered, and provides limited

opportunities for students to explore ideas actively (Mahardika et al., 2023). In fact, physics as a branch of natural science plays a crucial role in fostering logical, systematic, and creative thinking skills. Effective physics learning should not only focus on conceptual understanding but also encourage students to develop diverse strategies for solving real-world problems (Pawestri Primastuti et al., 2023; Xu et al., 2024).

One of the topics that strongly requires creative thinking skills is Uniformly Accelerated Motion (UAM). This topic is a fundamental concept in kinematics and provides multiple forms of representation, including graphs, mathematical equations, and real-life motion interpretation, which allow students to approach problems in various ways (Putra & Sari, 2022; Aprianti et al., 2023).

However, students' creative thinking skills in learning UAM are still relatively low. Students tend to rely on formula-based procedures without exploring alternative strategies such as graphical analysis or modeling. This condition indicates that key indicators of creative thinking, such as fluency, flexibility, and originality, have not been optimally developed (Saomi & Kade, 2021).

The results of interviews with physics teachers also revealed that students are generally passive and less actively engaged in the learning process. When given open-ended questions, students tend to provide simple answers and are reluctant to explore new approaches. This finding highlights the need for instructional innovation that actively involves students and fosters their creative thinking skills.

One potential solution is the development of experiment-based teaching aids. Teaching aids enable students to directly observe physical phenomena, thereby increasing engagement and promoting creativity (Daniyati et al., 2023; Hidayat et al., 2023). In this study, a teaching aid called Kinetrac was developed, integrating kinematics experiments with the Tracker application. This media allows students to record motion, analyze position, velocity, and acceleration data, and visualize the results in graphical form (Handayani et al., 2022; Ristanto et al., 2024).

The use of Kinetrac is further enhanced by integrating the STEM (Science, Technology, Engineering, Mathematics) approach. This approach emphasizes the integration of scientific concepts with technology, engineering design, and mathematical analysis. Such integration is expected to support the development of creative thinking skills through active and meaningful learning experiences (Wised & Inthanon, 2024).

METHOD

This study employed a Research and Development (R&D) approach aimed at producing a learning medium in the form of the Kinetrac teaching aid and examining its effectiveness in improving students' creative thinking skills. The development model adopted in this study was the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) proposed by Branch (2009), which was adapted to suit the research context.

The development procedure followed the ADDIE model, which consists of five main stages:

1. Analysis: This stage identified learning needs and classroom problems through observation of UAM learning, student characteristics, learning concepts, and objectives. The findings indicated low student engagement and a predominantly theoretical learning process, highlighting the need for an experimental-based medium to support creative thinking.
2. Design: This stage involved designing the Kinetrac teaching aid and supporting materials such as student worksheets (LKPD), focusing on media specifications, learning scenarios, and alignment with creative thinking indicators.
3. Development: The Kinetrac teaching aid was developed as an inclined track with a moving object analyzed using the Tracker application. The product was validated by experts and tested on a limited scale to ensure feasibility and functionality, followed by revisions.
4. Implementation: The teaching aid was applied in classroom learning, where students conducted experiments and analyzed motion data using Tracker to complete tasks designed to stimulate creative thinking.
5. Evaluation: Evaluation was conducted formatively at each stage and summatively through student response questionnaires and pretest-posttest results to assess feasibility and effectiveness.

The research design used in this study was a quasi-experimental design in the form of a Non-Equivalent Control Group Design. This design involved two groups: an experimental class using the Kinetrac teaching aid and a control class using conventional learning. Both groups were given a pretest and posttest to measure the improvement in creative thinking skills.

The research subjects were grade X students of MA Mujahidin. The sample was selected using purposive sampling based on considerations of similar academic ability and initial levels of creative thinking skills. Class X A was assigned as the experimental group, while Class X B served as the control group.

Data collection techniques included questionnaires and tests. Questionnaires were used to obtain validation data from media and material experts, as well as students' responses to the use of the teaching aid. The questionnaire instrument employed a five-point Likert scale. Tests were administered in the form of essay questions as a pretest and posttest to measure students' creative thinking skills, covering indicators such as fluency, flexibility, originality, and elaboration.

The collected data were analyzed quantitatively. Media feasibility was analyzed using percentage scores from validation results. To test effectiveness, prerequisite tests including normality test (Shapiro–Wilk) and homogeneity test (Levene's test) were conducted. Furthermore, an independent sample t-test was performed to determine differences in creative thinking skills between the experimental and control groups.

The improvement of creative thinking skills was analyzed using the N-Gain test, calculated using the following formula:

$$(g) = \frac{S_{posttest} - S_{pretest}}{S_{maksimum} - S_{pretest}}$$

The N-Gain values were classified into three categories:

Rentang N-Gain	Kriteria Efektivitas
$g < 0{,}3$	Low
$0{,}3 \leq g < 0{,}7$	Medium
$g \leq 0{,}7$	High

Source: Richard R. Hake, 1998.

This classification was used to determine the effectiveness level of the Kinetrac teaching aid in learning.

RESULT AND DISCUSSION

This study developed a STEM-based learning medium in the form of the Kinetrac teaching aid for Uniformly Accelerated Motion (UAM). The development was motivated by preliminary findings indicating that physics learning was still dominated by teacher-centered methods, resulting in low student engagement and limited opportunities to develop creative thinking skills.

The Kinetrac teaching aid enables students to conduct experiments by observing motion on an inclined track, recording data, and analyzing relationships between displacement, time, and velocity using the Tracker application. This process supports active learning and encourages students to explore multiple problem-solving approaches.

The form of the teaching aid used in this study is presented in Figure 1.

Figure 1. The Kinetrac Teaching Aid

The feasibility of the developed media was evaluated through expert validation. The results showed that the media expert assessment reached 83.8%, categorized as *feasible*, while the material expert assessment reached 91%, categorized as *very feasible*. The overall feasibility percentage was 87.4%, indicating that the Kinetrac teaching aid is highly suitable for use in physics learning.

Table 1. Summary of Media Feasibility Validation

Validator	Score	Percentage	Category
Media Expert	4.19	83.8%	Feasible
Material Expert	4.55	91%	Very Feasible
Average	4.37	87.4%	Very Feasible

Prior to hypothesis testing, the data were analyzed using normality and homogeneity tests. The Shapiro-Wilk test indicated that all data were normally distributed (Sig. > 0.05), while the Levene test showed that the data were homogeneous (Sig. = 0.692 > 0.05). Therefore, parametric statistical analysis could be applied.

The effectiveness of the Kinetrac teaching aid was analyzed using an independent sample t-test. The result showed a significance value of 0.000 (< 0.05), indicating a significant difference between the experimental and control groups. This finding confirms that the use of Kinetrac has a significant effect on improving students' creative thinking skills.

Table 2. Independent Sample t-test Results

Variable	t-value	Sig. (2-tailed)	Significance Level	Interpretation
Posttest (Exp vs Control)	7.839	0.000	0.05	Significant

The results showed that the experimental group achieved an N-Gain score of 0.5228, categorized as *moderate*, while the control group obtained 0.2924, categorized as *low*. This indicates that the Kinetrac teaching aid is more effective than conventional learning methods.

Table 3. N-Gain Results

Group	N-Gain	Percentage	Category
Experimental	0.5228	52.28%	Moderate
Control	0.2924	29.24%	Low

Further analysis based on creative thinking indicators revealed that improvements occurred across all indicators, including fluency, flexibility, originality, and elaboration. The greatest improvement was observed in the elaboration indicator, indicating that students were able to develop and explain ideas in greater detail. Meanwhile, originality and flexibility showed relatively lower improvements, suggesting that higher-order thinking skills require continuous practice and longer learning duration.

Student responses toward the use of the Kinetrac teaching aid were highly positive, with an average percentage of **88%**, categorized as *very feasible*. This indicates that the media is attractive, easy to use, and supports learning activities effectively.

Table 4. Student Responses

Aspect	Percentage
Media Display	87.74%
Media Utilization	88.38%
Language	87%
Ease of Use	88.87%
Average	**88%**

Overall, the findings indicate that the Kinetrac teaching aid integrated with a STEM approach provides a more interactive and student-centered learning environment. The use of experimental activities combined with digital analysis through the Tracker application allows students to actively engage in observing, analyzing, and interpreting motion phenomena.

This learning process encourages the development of creative thinking skills, particularly in generating ideas (fluency), applying various approaches (flexibility), elaborating explanations (elaboration), and producing original responses (originality). Compared to conventional methods, the Kinetrac-based learning approach offers a more meaningful learning experience and contributes significantly to improving students' creative thinking skills.

CONCLUSION

Based on the results and discussion, it can be concluded that the STEM-based Kinetrac teaching aid developed for Uniformly Accelerated Motion (UAM) is highly feasible, with an overall feasibility percentage of 87.4%.

The developed Kinetrac teaching aid is also proven to be effective in improving students' creative thinking skills, as indicated by a significant difference between the experimental and control groups ($p < 0.05$) and an N-Gain score of 52.28%, which falls into the moderate category.

In addition, the learning media received positive responses from students, with an overall response percentage of 88%, categorized as very feasible. These findings indicate that Kinetrac is appropriate and effective to be implemented as an innovative physics learning medium to support the development of students' creative thinking skills.

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