

Development of a Cognitive Conflict-Based UNO Physics Card as a Science Learning Medium to Facilitate Misconception Reduction and Strengthen Higher-Order Thinking Skills

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Abstract

The urgency of this study lies in the need for innovative learning media that reduce physics misconceptions while strengthening students' higher-order thinking skills. This study was motivated by the high prevalence of student misconceptions in topics involving complex physical concepts, such as Newton's Laws, and by the need for interactive learning media capable of facilitating conceptual change in the era of the Kurikulum Merdeka. This study aimed to develop and examine the validity, practicality, and effectiveness of a cognitive conflict-based UNO Physics Card learning medium in reducing misconceptions and strengthening students' Higher Order Thinking Skills (HOTS). The study employed a Research and Development (R&D) method using the ADDIE development model (Analyze, Design, Develop, Implement, Evaluate). The limited trial involved 27 Grade VII students at MTs PSM Tanen. Data on theoretical feasibility were collected through expert judgment covering five aspects of validity: subject-matter expert validity, media expert validity, pretest-posttest instrument validity, teacher-response questionnaire validity, and student-response questionnaire validity, all of which were categorized as Very Valid. The practicality of the medium was examined through method triangulation by synchronizing three instruments: the Teacher Response Questionnaire, which obtained 88.63% (Very Practical); the Student Activity Observation Sheet based on Jean Piaget's mental phases, which obtained 90% (Highly Implemented); and the group Student Worksheet (LKPD) completion recap, which reached 100% (Fully Completed). Meanwhile, the effectiveness test using a One-Group Pretest-Posttest Design showed a substantial increase in students' mean score from 53.52 (pretest) to 78.96 (posttest), with a Normalized Gain (N-Gain) index of 0.55, classified as Moderate. Qualitative analysis of essay arguments indicated a clear transformation from speculative-intuitive reasoning toward systematic scientific causal reasoning consistent with formal laws of physics. Thus, the cognitive conflict-based UNO Physics Card met the criteria of validity, practicality, and high effectiveness in reducing persistent misconceptions and strengthening students' critical thinking skills on the topic of Motion and Force.

Keywords: *Uno Physics Card, Cognitive Conflict, Newton's Laws, Misconceptions, Hots.*

Introduction

Science learning at the junior secondary school level in the era of the Kurikulum Merdeka is designed to foster scientific literacy and deep conceptual understanding rather than merely memorizing physical formulas (Kemendikbudristek, 2022). In practice, however, the topic of Motion and Force, particularly Newton's Laws, often becomes a major learning obstacle because it involves a high level of abstraction and mathematical integration (Villarino, 2023s; Borliboune et al, 2025). Empirical classroom findings indicate that many students bring intuitive preconceptions derived from everyday experience, which unfortunately often conflict with formal laws of physics (Azahra & Wasis, 2024; Gritsch & Krumphals, 2026). This

phenomenon leads to persistent misconceptions that are resistant to conventional instruction (Yahya et al., 2026). For example, when students assume that an object requires a continuous force to keep moving, they reinforce a misconception that can hinder mastery of more advanced science concepts.

Theoretically, failure to reduce these misconceptions directly affects students' low Higher Order Thinking Skills (HOTS) (Pratama & Setyaningrum, 2021; Huda et al., 2025). HOTS requires a strong and accurate cognitive structure as its foundation; when the conceptual foundation is distorted, the processes of analyzing, evaluating, and creating cannot function optimally (Suwandi et al., 2025). Based on the preliminary study and post-learning reflection at MTs PSM Tanen, a pedagogical intervention is needed that is not merely informative but transformative, one that can challenge students' inaccurate cognitive structures. One theoretical approach considered effective for addressing this issue is cognitive conflict, in which students are confronted with anomalies that compel them to recognize inconsistencies between their intuitive reasoning and scientific reality (Kaniawati et al., 2019; Potvin, 2023).

Research on remediating physics misconceptions through various learning media has been widely conducted in recent years. Some researchers have focused on virtual simulations to visualize the forces acting on an object (Kurniasari et al., 2020). Other studies have used interactive digital modules or Android-based e-books to provide opportunities for independent learning (Trisnawati et al., 2023). In general, these studies reported improved conceptual understanding among trial groups because abstract visualizations could be represented more concretely through digital screens. Nevertheless, these recent studies have several notable limitations. Most digital learning media tend to be individualistic, thereby minimizing social interaction and peer-group discussion in the classroom. Conceptual reconstruction can be more effective when students are actively involved in social argumentation to defend or revise their ideas in accordance with their stage of mental development (Muthiyan et al., 2023). In addition, heavy dependence on digital devices and internet connectivity often creates technical constraints in schools with limited facilities, which may ultimately distract from the central goal of conceptual change.

Educational card games such as UNO cards have also begun to attract attention among education practitioners as a means of increasing learning motivation (Suwandi et al., 2025). However, most existing educational card developments remain limited to conventional functions, namely drill-and-practice activities or aids for memorizing science terms at lower cognitive levels (Muthiyan et al., 2023). Learning card games that are specifically integrated with a systematically designed cognitive-conflict learning syntax to reduce persistent misconceptions while simultaneously challenging students' HOTS through in-depth reasoning questions remain rare. Considering the current research landscape, a clear gap exists between theoretical classroom needs and the learning media currently available. On the one hand, teachers need practical, inexpensive, non-digital interactive media capable of stimulating collaborative group dynamics. On the other hand, such media must have a strong theoretical basis for facilitating assimilation, accommodation, and equilibration in students' cognitive structures when they experience cognitive conflict while responding to game challenges (Mufit et al., 2022).

This gap challenges the common assumption that card games are effective only for lower-level cognitive processes. The present study extends the function of card games into an interactive diagnostic and remedial instrument. By integrating problems based on physical anomalies into the cards, the medium shifts from mere entertainment to a cognitive-conflict

stimulus that requires students to dismantle speculative-intuitive reasoning and reconstruct it into systematic scientific causal reasoning consistent with formal laws of physics.

Based on the gap analysis above, this study addressed the following research questions: (1) What is the theoretical feasibility of the developed cognitive conflict-based UNO Physics Card? (2) What is the level of practicality of the medium when implemented in learning? and (3) How effective is the medium in reducing misconceptions and strengthening students' HOTS on the topic of Motion and Force? Accordingly, this study aimed to develop and examine the validity, practicality, and effectiveness of the UNO Physics Card using the ADDIE development model (Analyze, Design, Develop, Implement, Evaluate) (Alatas et al., 2025). The novelty of this study lies in the structural and substantive modification of conventional UNO cards into a UNO Physics Card that is systematically integrated with cognitive-conflict scaffolding and synchronized with Jean Piaget's mental phases through three conceptual stages, namely the Brain phase, the Lightning phase, and the Light phase. Through this approach, the developed medium is intended not only to reduce misconceptions but also to enhance motivation, cognitive engagement, and students' critical thinking through active group interaction.

Method

This study employed a Research and Development (R&D) approach to produce and test a cognitive conflict-based UNO Physics Card learning medium designed to reduce misconceptions while strengthening students' Higher Order Thinking Skills (HOTS). The study adapted the ADDIE development model, which is systematically organized into five main stages: Analyze, Design, Develop, Implement, and Evaluate. These stages were arranged logically so that the media-development process could be conducted in a directed and measurable manner. During the analysis stage, empirical problems related to the high level of misconceptions and the needs of the school science curriculum were identified. The design stage focused on preparing the educational-card blueprint by integrating three cognitive-conflict phases and synchronizing them with Jean Piaget's mental phases. The development stage involved producing the physical card product, developing the HOTS essay-reasoning test instrument, and validating the product with subject-matter and media experts. During the implementation stage, the study applied a quasi-experimental One-Group Pretest-Posttest Design to examine the effectiveness of the medium in reducing misconceptions and strengthening Higher Order Thinking Skills (HOTS). The structure of the testing design is summarized in Table 1.

Table 1. *One-Group Pretest-Posttest Design*

Pretest	Treatment	Posttest
O1	X	O2

In this design, O1 represents the initial test score (pretest) before students used the medium, X represents the treatment in the form of learning using the cognitive conflict-based UNO Physics Card, and O2 represents the final test score (posttest) after students received the intervention using the medium. The research subjects and sample population in this study were Grade VIII students at MTs PSM Tanen. Sampling was based on specific characteristics using purposive sampling. The selected class was identified as having the highest level of misconceptions on the topic of Motion and Force based on the supervising teacher's recommendation and post-learning reflection results. This sample was considered appropriate for examining the effectiveness of the UNO Physics Card in stimulating students' conceptual

change. During classroom implementation, students were divided into several small groups to play the card game collaboratively and stimulate peer-group argumentation and discussion.

Data collection was designed comprehensively to capture quantitative and qualitative data corresponding to three main indicators of product success: feasibility (theoretical validity), practicality, and effectiveness. Theoretical feasibility was measured using expert-judgment validation sheets completed by university experts and science-education practitioners to assess the appropriateness of the science content and media design. Practicality was measured using student-response questionnaires and learning-implementation observation sheets completed by observers during classroom implementation. Meanwhile, data on media effectiveness were collected through higher-order essay-reasoning questions integrated with physical-anomaly problems to measure the reduction of student misconceptions through pretest and posttest scores.

Quantitative and qualitative data were analyzed descriptively to draw valid conclusions from the collected data. Quantitative data from expert-validation sheets and teacher-response questionnaires were analyzed by calculating the mean percentage score using the following percentage formula: $P = \frac{f}{N} \times 100\%$. In the formula, P represents the percentage of media feasibility or practicality, f represents the total empirical score obtained from validators or practitioners, and N represents the maximum possible score. The resulting percentages were then converted into categorical criteria to determine the level of validity and practicality of the medium in classroom implementation.

The data-analysis technique combined quantitative and qualitative descriptive approaches to address the research questions without presenting unnecessarily complex mathematical visualizations in the manuscript. Theoretical-feasibility data from experts and practicality data from student-response questionnaires were analyzed using descriptive quantitative techniques by calculating the percentage of the obtained score relative to the ideal maximum score, which was then converted into product-feasibility and practicality categories. To analyze effectiveness in reducing misconceptions and strengthening HOTS, students' pretest and posttest scores were calculated using the normalized gain index (N-Gain) to identify cognitive improvement before and after the intervention. The resulting Gain index was then interpreted using the Gain-index criteria proposed by previous studied, as summarized in Table 2, to determine its effectiveness classification (Hake, 1999).

Table 2. *N-Gain Score Classification Criteria*

N-Gain Score Range	Effectiveness Classification
$g > 0.7$	High
$0.3 \leq g \leq 0.7$	Moderate
$g < 0.3$	Low
$g \leq 0$	Failed

In addition, non-test data were analyzed through data reduction, data display, and conclusion drawing to interpret qualitative information obtained from observation sheets and field notes. The trustworthiness of these data was subsequently examined through data triangulation to ensure the objectivity and validity of the research findings.

Results

The implementation of the cognitive conflict-based UNO Physics Card for the topic of Motion and Force (Newton's Laws) in Grade VII at MTs PSM Tanen followed the Research and Development (R&D) procedure within the ADDIE framework (Analysis, Design, Development, Implementation, Evaluation). The findings from each development phase began with the analysis stage, which focused on a comprehensive mapping of learning needs, learner characteristics, and initial misconceptions. Curriculum analysis confirmed the need for innovative interactive learning aids capable of concretely visualizing abstract mechanics concepts in order to support the Learning Outcomes (Capaian Pembelajaran/CP) for Science Understanding within the Kurikulum Merdeka. Analysis of the student profile indicated that Grade VII students were in a cognitive transition from the concrete-operational stage toward the formal-operational stage and demonstrated strong enthusiasm for gamification-based learning. Meanwhile, the preliminary study revealed persistent misconception patterns regarding Newton's Laws, with most students holding intuitive Aristotelian views, such as the belief that a constant force is absolutely required to keep an object moving at constant velocity.

Based on these analysis findings, the study proceeded to the design stage, in which the UNO Physics Card blueprint was developed by integrating the levels of Newton's Laws content with a cognitive conflict-based learning sequence. The product employed a three-color coding system to distinguish content: Blue represented Newton's First Law, Yellow represented Newton's Second Law, and Red represented Newton's Third Law. Each color category contained five numbered cards representing conceptual content that students were required to solve. The structure of each card number was arranged hierarchically through three consecutive cognitive-conflict phases. The initial phase presented visual prompts or basic questions to reconstruct prior knowledge. The conflict phase presented anomalous phenomena accompanied by QR Codes linked to concrete videos, confronting students' intuitive conceptions with formal scientific reality. The resolution phase then guided students toward deeper conceptual reasoning, supported by instructions for exploring the PhET Physics virtual laboratory to reduce misconceptions while training Higher Order Thinking Skills (HOTS).

After the design blueprint was completed, the study proceeded to the development stage, in which the draft design was transformed into a ready-to-use physical product printed on 310-gsm Art Paper with matte lamination in an ergonomic size of 6.3 × 8.9 cm. The physical product was complemented by a group Student Worksheet (LKPD) to guide students' reasoning process and regulate the game procedure. The media prototype was then examined for theoretical feasibility through expert judgment by a validation team consisting of two university lecturers specializing in science education and one practicing teacher. A quantitative summary of the expert evaluations is presented in Table 3.

Table 3. *Theoretical Validation Results of the UNO Physics Card*

No.	Assessment Aspect	Feasibility Percentage	Category
1	Content (Newton's Laws)	87.50%	Very Valid
2	Media Design and Visual Aesthetics	89.20%	Very Valid
3	Evaluation Instrument (Pretest-Posttest)	86.00%	Very Valid
Total		87.56%	Very Valid

The data in Table 3 show an overall mean theoretical-feasibility index of 87.56%, categorized as Very Valid. The highest percentage was obtained for typography readability and technical media aspects (89.20%), followed by content feasibility (87.50%) and evaluation-

instrument suitability (86.00%). Although the product had met the overall feasibility criteria, the validation team provided several qualitative suggestions to improve the aesthetics and functional clarity of the cards. Revisions focused on visual layout, font-size adjustment, and clearer presentation of anomalous phenomena through the QR Codes. A comparison of the physical appearance of the UNO Physics Card before and after revision is summarized in Table 4.

Table 4. Comparison of the UNO Physics Card Before and After Revision

No	Validator	Aspect Revised	Before Revision	After Revision	Description of Changes
1	Rohmatus Syafi'ah, M.Pd.	Instructions for Use and Learning Outcomes	Learning outcomes and learning objectives had not yet been included at the beginning of the medium.	Learning outcomes and learning objectives were added to the LKPD and media packaging.	The revision was made to clarify the direction of learning from the beginning of media use.
2	Rohmatus Syafi'ah, M.Pd.	Citation of Literature Sources	Source citations had not been included for each concept or definition.	Source citations were added to the back of the initial-phase cards, particularly for Newton's Laws concepts.	Citations were added to strengthen the validity of the content and information sources.
3	Rohmatus Syafi'ah, M.Pd.	Explanation of Formulas and Symbols	Concept explanations were written in a less direct manner.	Concept explanations were clarified (ΣF is explained as the total resultant force).	The wording was simplified to make the concepts easier for students to understand.
4	Rohmatus Syafi'ah, M.Pd.	Consistency of Physics Symbols	The physics symbols used had not been fully aligned with the students' textbook.	The physics symbols were adjusted to relevant notation consistent with the students' textbook.	The symbols were aligned so that the content would be more consistent with the primary learning resource.
5	Rohmatus Syafi'ah, M.Pd.	Alignment of Questions and Illustrations	The questions and illustrations for slippery and rough floor conditions had not been presented in a balanced manner.	The questions and illustrations were revised by adding a clearer comparison between slippery and rough floor conditions.	The revision was made to help students distinguish the phenomena and understand the concept more easily.
6	Ely Tri Wijayanti, M.Si.	LKPD Title Writing	The titles on the blue, red, and yellow LKPDs were still written as Newton's Law 1.	The LKPD titles were revised to Newton's First, Second, and Third Laws.	The revision was made to align the titles with scientific writing conventions.
7	Arini Fuadatus, S.Pd.	Clarification of the Media Function	The cognitive-conflict and gamification strategies were considered appropriate, but the function of the medium still needed to be emphasized.	The cognitive-conflict and gamification strategies were retained because they were considered to support the reduction of misconception indications, increase student engagement, and strengthen HOTS in accordance with the media-development objectives.	No major changes were made because the approach used was consistent with the development objectives.

As shown in Table 4, the revisions generally improved the readability, conceptual accuracy, and visual clarity of the UNO Physics Card. Language adjustments and simplified descriptions of formulas helped reduce the potential for misconceptions among students. In addition, sharper visual illustrations of anomalous phenomena, such as comparisons between slippery and rough floor conditions, together with the alignment of physics symbols, made the content more concrete. After these revisions were completed, the medium was considered valid and met the aesthetic and functional standards required for classroom use.

After all feedback from the validation team had been addressed, the final prototype of the UNO Physics Card was produced. The medium was systematically designed by integrating three main cognitive phases (Initial, Cognitive Conflict, and Evaluation/Analysis), supported by a group LKPD and practical packaging. The overall characteristics, components, and functions of the final product are summarized in Table 5.

Table 5. *Structural and Functional Specifications of the Cognitive Conflict-Based UNO Physics Card (Final Product)*

Media Component	Category/Phase	Text and Visual-Structure Specifications	Pedagogical/ Cognitive-Conflict Function
Learning Cards (3 Phases)	Initial Phase	Front: Contains the card number, concept name, and an illustration of an everyday physics phenomenon. Back: Contains a formal scientific explanation, basic mathematical equations, and supporting literature citations.	Identifies prior understanding and facilitates the integration of basic physics concepts relevant to students.
	Cognitive Conflict Phase	Front: Contains illustrations of anomalous or contradictory phenomena that stimulate reasoning questions. Back: Contains an interactive QR Code (link to a PhET simulation or phenomenon video) and prompting questions	Challenges students' misconceptions by presenting evidence that contradicts their initial assumptions.
	Resolution Phase	Front: Contains a case scenario or an application of Newton's Laws in a new situation. Back: Contains guidance for causal analysis and instructions for scientific problem solving.	Trains Higher Order Thinking Skills (HOTS) and reconstructs students' conceptual understanding into coherent scientific understanding.
Supporting LKPD	Student Worksheet (LKPD)	Contains group identity, learning indicators, instructions for exploring digital media/PhET, and response spaces for reasoning discussions.	Guides scientific workflow and group collaboration during the conceptual-reconstruction process.
Packaging	Media Container	<i>A storage box made of art paper with water-resistant lamination, equipped with game instructions and color coding according to phase level.</i>	Maintains organization and facilitates the distribution of cards according to learning phases in the classroom.

The specifications in Table 5 show that the UNO Physics Card functions not only as a game medium but also as a cognitive conflict-based instructional instrument. The cards are systematically divided into three phases that guide students through successive stages of thinking, from identifying prior understanding, experiencing disequilibrium when encountering anomalous phenomena, to reconstructing a coherent scientific understanding. The integration of QR Codes in the conflict-phase cards also broadens students' access to interactive digital learning resources. To provide a detailed visual description of the revised final product, an example of the UNO Physics Card is presented in Figure 1. The displayed card represents the Cognitive Conflict Phase, with the front side presenting an anomalous phenomenon designed to trigger students' misconception-based reasoning and the back side containing an interactive QR Code linked to a PhET simulation together with supporting scientific concept descriptions.



Figure 1. Visual Appearance of the Final UNO Physics Card Product: Front Side (Cognitive Conflict Phenomenon) and Back Side

Figure 1 illustrates the optimized layout, color coding, and clarity of physics symbols following revisions based on the validation team's feedback. The QR Code on the back of the card directly connects the physical card-game activity with digital exploration through a PhET simulation, enabling students to test and reconstruct their conceptual understanding independently or collaboratively. This combination of aesthetic consistency and functional clarity indicates that the UNO Physics Card was ready for implementation in the limited field trial. After the physical product prototype was declared valid and ready for use, the study entered the implementation stage, in which a limited-scale trial was conducted in Grade VII A at MTs PSM Tanen involving 27 students. The operational practicality of the medium was measured using a triangulation technique that combined teacher-response questionnaire data, observations of students' scientific activities, and completion of group LKPDs. The practicality results are presented in Table 6.

Table 6. Practicality Test Results of the UNO Physics Card

Practicality Component	Measurement Parameter	Effectiveness Score	Qualification
Teacher Practitioner Response	Perception Questionnaire	88.63%	Very Practical
Student Activities	Student Observation Sheet	90.00%	Highly Implemented
LKPD Completion	Group Document Evaluation	100.00%	Fully Completed

Table 6 presents the operational-practicality assessment from three different instruments used during the learning process. The teacher-response questionnaire obtained 88.63%, indicating that the medium helped the teacher manage the class and efficiently stimulated student participation. The implementation of students' scientific activities observed through the activity sheet reached 90.00%, supported by group LKPD completion data that reached 100.00%. The convergence of these triangulated data indicates that the UNO Physics Card was highly practical to use, that students could readily understand the procedure, and that the medium supported efficient classroom time management. The ADDIE sequence concluded with the evaluation stage, which aimed to analyze the effectiveness of the medium in facilitating students' conceptual change using a One-Group Pretest-Posttest Design. Effectiveness was measured through changes in the class mean cognitive score, as illustrated in Figure 2.

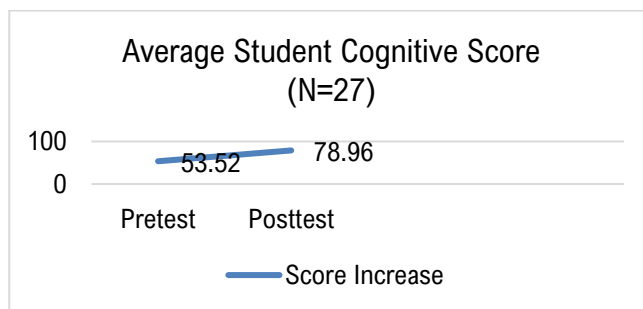


Figure 2. Comparison of Cognitive Achievement Before and After the Intervention

Figure 2 shows a clear contrast between students' cognitive achievement before (pretest) and after (posttest) the UNO Physics Card intervention. The class mean increased by 25.44 points, from an initial score below the passing criterion of 53.52 to 78.96 at the final assessment. To examine the magnitude of conceptual improvement, the analysis was continued using normalized gain, resulting in an N-Gain value of 0.55. This value falls within the Moderate category and provides empirical evidence that the interactive medium was effective in facilitating cognitive reconstruction and reducing physics misconceptions at the class level on the topic of Motion and Force.

In addition to the overall increase in cognitive scores, analysis of students' answer sheets indicated a substantial reduction in misconceptions related to Newton's Laws. Before the intervention (pretest), many students demonstrated persistent misconceptions about Newton's First Law, such as the intuitive belief that a moving object requires a continuous force, and about Newton's Third Law. After using the UNO Physics Card, students' posttest response patterns shifted from speculative-intuitive reasoning toward formal scientific understanding, with the proportion of misconception-based responses substantially reduced. Strengthening of Higher Order Thinking Skills (HOTS) was also reflected in the improved quality of students' essay arguments. In the pretest, students generally responded at lower cognitive levels (C1-C2). In the posttest, however, students were able to explain causal relationships in anomalous phenomena and systematically evaluate relationships among physics variables, reflecting achievement of the Analyze (C4) and Evaluate (C5) indicators associated with Higher Order Thinking Skills.

Discussion

The successful implementation of the cognitive conflict-based UNO Physics Card on the topic of Motion and Force (Newton's Laws) demonstrated a substantial effect on students' conceptual restructuring. The characteristics of the medium, which integrated three levels of Newton's Laws content (Blue, Yellow, and Red) within a hierarchical numbering system and three cognitive phases, supported a shift in students' reasoning from intuitive-Aristotelian thinking toward formal scientific conceptions. The mechanical and pedagogical strengths of the medium are discussed through the following three analytical pillars. The deconstruction of misconceptions began systematically through the Initial and Conflict card phases. Newton's Laws have historically been among the physics topics most susceptible to persistent misconceptions because they often conflict with students' everyday sensory experiences. Students tend to believe that an object will immediately stop moving when an external force is removed, or that the action force is always greater than the reaction force on the object that appears to lose the interaction (Kurniawan et al., 2024). The UNO Physics Card addressed this mental barrier systematically, beginning with the Initial Phase. In this phase, the cards activated students' prior knowledge of basic force concepts. This structure is consistent with constructivist perspectives emphasizing that activation of prior knowledge is an essential foundation before more complex concepts are introduced into students' cognitive structures (Slavin, 2020). This is reinforced by previous findings indicating that failure to understand basic physics concepts often results from neglecting students' initial conceptions derived from everyday experience (Mushthofa et al., 2020).

A more pronounced destabilization of students' alternative conceptions occurred when they entered the Conflict Phase. Cards in this phase presented anomalous events that induced mental disequilibrium. Through QR Codes integrated immediately before the problem text,

students viewed videos of real phenomena that directly confronted their inaccurate intuitions with scientific reality. According to the conceptual change model, this disequilibrium is a prerequisite that compels students to recognize the limitations of their initial concepts and generates dissatisfaction with previous cognitive schemes. Smartphone-based video viewing provided visual evidence of the physical anomaly, making the contradiction difficult to dismiss. This is consistent with previous studies reporting that cognitive-conflict strategies supported by digital media are effective in reducing student misconceptions in abstract mechanics topics (Sari et al., 2019).

The next stage involved conceptual reconstruction through the Resolution Phase supported by PhET simulations. After students' initial cognitive structures had been challenged during the conflict phase, the UNO Physics Card provided a bridge toward resolution. Rather than presenting immediate answers, this phase guided students through in-depth causal analysis to reduce misconceptions more durably. Selected cards were strengthened through integration with the PhET Simulation virtual laboratory. The combination of resolution cards and PhET simulations provided concrete and manipulable learning experiences for Grade VII students who were psychologically transitioning from concrete-operational to formal-operational thinking. Through PhET simulations, abstract variables such as net force, air resistance, and acceleration could be dynamically visualized and independently manipulated by students. Theoretically, this interactive visualization meets the intelligible and plausible criteria in the conceptual-change process. This finding is supported by empirical research showing that virtual laboratories such as PhET, when used after a cognitive-conflict phase, can accelerate students' mental accommodation and help new scientific concepts remain longer in memory (Putri et al., 2021). Students arrived at Newtonian concepts not through formula-based indoctrination but through reinvention, as reflected in the increase in the mean posttest score to 78.96.

The discussion was further extended by examining the effects of gamification on scientific activity and critical thinking (HOTS). The high implementation rate of students' scientific activities (90.00%) and the complete group LKPD completion rate (100.00%) suggest that the adoption of card-game mechanics successfully reduced learning anxiety toward physics. The healthy competitive atmosphere of the card game encouraged active engagement. Each time students attempted to solve a challenge associated with a card number, whether Blue, Yellow, or Red, they were required to discuss, defend arguments, or evaluate other group members' ideas in order to progress in the game. These small-group social dynamics facilitated peer scaffolding in accordance with Vygotsky's sociocultural principles. Research on modified UNO card learning also indicates that the element of fun in gamification can stimulate students' intrinsic motivation to solve complex reasoning problems without feeling excessively burdened (Heri et al., 2025). The implications of this intensive interaction are reflected in the N-Gain index of 0.55 (Moderate category). Through the three hierarchically designed card phases, students were not limited to lower-level cognitive processes such as memorizing Newton's Laws (C1/C2). The anomalous questions in the conflict phase and the requirement to analyze phenomena in the resolution phase trained students' critical thinking and problem-solving skills at the Analyze (C4) and Evaluate (C5) levels that characterize Higher Order Thinking Skills (HOTS), in line with the scientific-literacy demands of the Kurikulum Merdeka (Lestari & Annizar, 2020).

Conclusion

This study aimed to examine the feasibility, practicality, and effectiveness of a cognitive conflict-based UNO Physics Card in reducing misconceptions and facilitating the strengthening of students' HOTS on the Grade VII Motion and Force (Newton's Laws) topic at MTs PSM Tanen. The findings confirmed that the product was theoretically Very Valid with an index of 87.56%, highly practical to implement with scientific-activity implementation reaching 90.00% and LKPD completion reaching 100.00%, and effective in improving students' cognitive understanding from a mean score of 53.52 to 78.96, with an N-Gain of 0.55 (Moderate category). In terms of implications, the integration of cognitive-conflict syntax through QR Code-supported card gamification and PhET simulations provided a new instructional contribution to restructuring intuitive-Aristotelian misconceptions into formal physics understanding. Nevertheless, this study was limited to a small-scale trial involving one experimental class of 27 students using a One-Group Pretest-Posttest Design without an external control class. Future research is therefore recommended to expand field testing to more heterogeneous populations, adopt a quasi-experimental design involving a control class, and include a delayed posttest to measure the retention of scientific understanding in students' long-term memory.

Acknowledgment

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