Jurnal Riset dan Kajian Pendidikan Fisika
Vol. 11, No. 2 [October 2024], pp. 49-60

e-ISSN: 2355-620X
DOI: 10.12928/jrkpf.v11i2.718

Students needs investigation on learning newton's law of physics: explanatory sequential

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Abstract

This study aims to determine the needs of students in learning physics, explicitly focusing on Newton's Law. The respondents included 149 students and three physics teachers from high schools (SMA) across Malang Regency and Malang City. Respondents were selected using a random sampling technique. The research instruments used were questionnaires and interview guidelines. Data analysis was conducted qualitatively, with coding and categorization applied to the questionnaire data. Nine respondents were then selected for interviews, and the transcribed interview data were used to complement the questionnaire findings. The study found that students preferred three learning models: practical experiments, observation, and reading. In particular, 61.2% of high school students in the city favored learning through practical experiments, which began with observing Newton's Law phenomena and was reinforced by hands-on practice. Meanwhile, 45.7% of district high school students preferred learning through observation, emphasizing instructional media such as videos, physics demonstrations, and guided discussions on physics-related problems. The results of this study are expected to inform the implementation of learning methods that accommodate the specific needs identified among students.

Keywords: investigative learning, learning needs, learning styles, newton's laws

Received 6 March 2024, Revision 11 September 2024, Accepted for publication on 5 October 2024.
https://doi.org/10.12928/jrkpf.v11i2.718

I. Introduction

Newton's Law is a fundamental concept in physics that explains motion-related phenomena, specifically addressing the relationship between mass, acceleration, and the forces acting on objects [1]. Despite its significance, research shows that students' mastery of Newton's Law must improve. A study by [2] reported that students' average score on a Newton's Law concept mastery test was only 7.16 out of 100, indicating considerable difficulty understanding the topic. These difficulties include challenges in translating problems into the language of physics [3], [4], comprehending mathematical equations [5], misconceptions about force and motion, identifying forces acting on an object [6], and determining the magnitude of forces within a system [7], [8]. Difficulty in identifying the magnitude and direction of forces further complicates students' ability to determine the resulting acceleration [9]–[11]. These issues underscore the need for effective approaches to teaching physics concepts like Newton's Laws.

Learning motivation is crucial to students' success in meeting educational goals. Students' intrinsic and extrinsic motivation levels determine the effort they dedicate to learning activities. Prior studies consistently demonstrate a strong relationship between learning motivation and academic performance [12], [13]; the

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higher a student's motivation, the more likely they are to perform well academically [12]. Low motivation often hinders students from achieving their full learning potential. When motivation is lacking, students may disengage from key learning activities, such as reading course materials, completing assignments, or participating in class discussions, reducing their understanding of the concepts taught and negatively impacting learning outcomes. This issue is particularly evident with Newton's Laws, where many students need more motivation to grasp abstract physics concepts. Recognizing the importance of learning motivation in enhancing academic achievement, educators, parents, and other stakeholders need to focus on building and reinforcing student motivation. Student motivation can be increased by creating a supportive learning environment, providing positive feedback, and recognizing achievements. Addressing factors that diminish motivation, such as learning challenges, academic pressure, and limited social support, is critical.

One effective strategy to address learning challenges with Newton's Laws is to incorporate a variety of learning models. Student-centered, inquiry-based approaches encourage students to actively construct their understanding, which is especially beneficial in science education, where the goal is to foster critical thinking skills, scientific attitudes, and environmental awareness [14]. Inquiry-based learning, in particular, can enhance motivation and foster a deeper conceptual understanding [15]. However, challenges such as limited time within the curriculum and the need to manage diverse student needs in a structured learning environment may present obstacles.

In light of these challenges, this study aims to analyze high school students' learning needs regarding Newton's Law. Findings from this needs analysis can inform physics educators and curriculum developers in selecting appropriate instructional models, supporting optimal learning, and helping students achieve the desired learning outcomes.

II. Methods

This research used an explanatory sequential approach. The method refers to Creswell's approach, which aims to explain and interpret quantitative data through the collection and subsequent analysis of qualitative data [16]. This research will be conducted in two stages. The first stage is to collect quantitative data through a questionnaire survey. Data collection uses a questionnaire distributed to 67 high school students in Malang City and 82 high school students in Malang Regency. Respondents were asked to fill out a questionnaire using the Google form link.

Furthermore, in the second stage, namely the qualitative data collection stage. Respondents in the second stage were selected based on the answers to the survey questionnaire. There are three respondents from each category to be interviewed, so there are nine respondents.

The instruments used were both survey questionnaires and interview guidelines. The survey questionnaire is an initial needs questionnaire consisting of 8 open questions in a Google form. The questions in the questionnaire and interviews were developed with the theme of student needs in the implementation of learning in order to obtain better learning outcomes; these questions were developed based on research by [17] showing the need for learning by paying attention to student needs so that learning outcomes can be maximized, other research by [18] concluded that teachers and learning media that suit their needs can support the learning process of students and get better learning outcomes.

Data analysis was carried out in two stages: quantitative data analysis. Quantitative data analysis was done by categorizing student answers into various themes or categories. Furthermore, the percentage calculation was carried out on the frequency of student answers. The second stage was qualitative data analysis. Qualitative data from interviews were analyzed using a coding approach and thematic analysis. In the first stage, interview data was transcribed and analyzed through an open coding process, where students' responses were grouped based on naturally occurring themes related to their learning needs. This coding process was conducted to identify relevant patterns and categories, such as learning method preferences and barriers to understanding Newton's Law. Next, thematic analysis was used to explore the meaning behind each identified theme. In this analysis, key themes, such as the learning needs of practicum, observation, and practice questions, were further explored to understand their relationship with students' motivation and learning outcomes. Each theme is then interpreted to provide a comprehensive picture of students' needs in physics learning, particularly on Newton's Laws.

III. Results and discussion

Results

Data analysis used qualitative analysis. The data was then processed using coding techniques to identify patterns and themes from respondents' answers. Furthermore, the respondents' answers were grouped based on the emerging themes and interpreted in percentages.

Based on questionnaires and interviews, various types of student needs in learning Newton's Law in physics were found; the various variations of data were then grouped into three categories: reading, observing, and practicum. Table 1 shows the data in the form of percentages obtained from the questionnaire *"What do you need in physics learning?"* The table assigns a number to each school type.

Table 1. Percentage category of learning method needs desired by students

Category	High School in City	High School in Distric
Reading	4 Students (6%)	5 Students (6.2%)
Observing	16 Students (23.9%)	37 Students (45.7%)
Prakticum	41 Students (61.2%)	32 Students (39.5%)
Choice Combination	6 Students (9%)	7 Students (8.6%)

The data shows the type of learning expected by students so that students can be more motivated and understand Newton's Law material better. With a more complete explanation as follows:

1. Learning that is classified as reading

Learning based on student needs in the reading category is classified as a reading and writing learning style. Students in this category are too few in both types of schools; students in the learning by reading category prefer to learn independently as one interview respondent from Kabupaten High School said: *"I expect the use of learning resources that are valid and mutually agreed upon because I like to learn by reading it myself,"* another reason respondents like learning by reading category is that students prefer learning to be carried out with question exercises independently and periodically or scaffolding as the opinion of one respondent from City High School: *"The existence of practice questions after learning the material will be better, I can understand each concept of Newton's Law gradually."* Based on the data in the questionnaires and interviews, the grouping of student needs in the reading category is divided into two points of learning needs, namely written learning resources and gradual question exercises or scaffolding with the following explanation:

a. Written learning resources

Students expect various learning activities involving reading to understand Newton's law material. Written learning resources allow students to access materials independently outside of class hours to learn more flexibly according to their individual needs and level of understanding. With the existence of diverse and easily accessible written learning resources, it is expected that students can improve their understanding of Newton's law material and obtain better learning outcomes. From the opinions of interview respondents and the opinions of respondents from the questionnaire that have been summarized, it can be concluded that one of the expectations of students is the existence of written learning resources that include various formats, such as textbooks, presentations, written works, and websites.

b. Practice problems or scaffolding questions

In learning physics in high school, students expect a variety of learning activities that include practice problems or scaffold problems in learning Newton's law. Students expect practice problems tailored to the difficulty level of Newton's law material, which can help them test their understanding of the concepts and apply physics principles in different situations. With varied and systematically organized practice problems, students are expected to develop better problem-solving skills and improve their understanding of Newton's law. Therefore, practice problems and scaffold problems are considered as one of learning activities that are highly expected by students in learning Newton's law material.

2. Learning that is classified as observing

Learning based on students' needs in the observing category is classified into audio and visual learning styles. The number of students in the learning category at Regency High School is much higher than that of City High School students. One of the opinions of respondents from Regency High School who liked learning through observation said that learning through video learning media can be used as an evaluation and reinforcement in learning by giving a statement: *"Learning in class I think it is enough, but by providing videos or other learning media can help me to repeat learning in class so that I understand better and remember more easily."* The respondent from SMA Kota, who liked learning through observation, said that he liked learning physics with demonstrations presented by stating: *"The demonstration makes me more willing to learn, not just make this lesson (Physics on Newton's Law) a compulsory lesson."* The grouping of student needs in the reading category is based on the learning choices of students who use audio and visual learning styles classified into three main need points, namely the need for learning media through videos, demonstrations, and discussion of problems or problem-solving with detailed explanations as follows:

a. **Video learning media**
Students expect learning media in the form of videos to facilitate the process of observing physics concepts visually. Learning videos can effectively illustrate the basic principles of Newton's laws, such as the laws of motion, Newton's second law, and Newton's third law, in a more dynamic and understandable way. Using animations, simulations, and visual demonstrations, students can directly observe how objects interact in physical systems per Newton's laws. Thus, video learning media not only provides a more engaging and interactive learning experience for students but also helps them to understand complex physics concepts better through direct observation.

b. **Demonstration**
Students expect learning that involves live demonstrations. Physics demonstrations by teachers or learning facilitators help students observe physics concepts practically and directly. For example, using tools such as miniature cars and tracks, teachers can demonstrate Newton's laws of motion by showing how the force exerted on an object affects its acceleration and motion. Through this demonstration, students can observe physics phenomena in real time, gain a deeper understanding of physics principles, and establish a connection between theory and its practical application in everyday life. Thus, learning through demonstration not only facilitates the observation of physics concepts but also increases students' engagement and understanding of the learning materials.

c. **Discussion to work on problems or problem-solving with teacher guidance**
Students expect teacher-guided group discussions to work on problems or problem-solving related to Newton's laws. Group discussions allow students to observe different points of view and approaches to solving complex problems. With direct guidance from the teacher, students can observe effective problem-solving strategies and receive immediate feedback on their process of solving the problems. Group discussions also facilitate collaboration between students, allowing them to observe and learn from each other. Through these discussions, students not only hone their observational skills in analyzing physics problems but also strengthen their understanding of the practical application of Newton's laws in real-life problem-solving.

3. Learning that is classified as a practicum

Learning needs categorized in practicum are classified as kinesthetic learning styles. The number of respondents who chose learning needs in this category in City High School and Regency High School was too high, especially in City High School, with the percentage of voting respondents exceeding the total voting respondents in the previous two categories. One of the interview respondents, a Kota High School student, gave the opinion that learning through practicum and real phenomena can help him to understand and use the concept of Newton's Law better by stating: *"Practicum is a fun method to learn; students can learn directly from the origin (real phenomena) rather than just theories that I cannot understand where and how they originated."* The grouping of student needs in the practicum category based on student learning choices is classified into two main need points, namely the need for real phenomena brought to class and practicum and its reporting with detailed explanations as follows:

a. **Learning with Newton's Law phenomenon**
Students expect hands-on experience with Newton's Law phenomena brought directly into the classroom. Bringing Newton's Law phenomena into the classroom allows students to interact directly with fundamental physics concepts and see these principles in action in controlled situations. For example, students can observe simple experiments that demonstrate the laws of motion, Newton's second law, or the action-reaction principle. With this experience, students not only hear or read about Newton's laws

but can also see them at work in real life, which can strengthen their understanding of those physics concepts. Therefore, bringing the phenomenon of Newton's Laws into the classroom as part of physics practicum provides a fun and meaningful learning experience for students, helping them understand and internalize physics concepts better.

b. Students conduct practicum related to Newton's Law material

The need for students to engage in practicum related to Newton's Law material and then make reports and discussions is essential. This practicum provides opportunities for students to experience physics concepts directly through controlled experiments. Through this practicum, students can gain a deeper understanding of Newton's laws of motion and their application in real-world situations. Upon completion of the practicum, students need to produce a report and discussion, allowing them to reflect on their findings systematically. This process helps students clarify their understanding of the physics concepts they are learning and hone their scientific writing and critical thinking skills. Thus, through practicum and report writing, students can develop a deep understanding of Newton's laws while improving their ability to present and communicate experimental findings effectively.

Discussion

1. Reading

a. Written Learning Resources

Visual language is essential in physics education, effectively conveying complex concepts and enhancing understanding [19], [20]. Integrating visual aids, such as graphics and images, with text is essential in textbooks, as it supports the integration of physical displays with related information [21]. Visual representations in textbooks should focus on graphics presentation and their integration with appropriate text [22].

Students who expect physics learning on Newton's Law material with written learning resources can utilize various learning resources, such as textbooks, modules, and scientific articles. Written learning resources can assist students in understanding physics concepts in a more structured and systematic way. In addition, written learning resources can also help students prepare themselves before participating in classroom learning so that students can be more prepared and confident in participating in physics learning [23]. Using written learning resources in physics learning can also help students overcome difficulties in understanding physics concepts. Written learning resources can provide a more detailed and in-depth explanation of physics concepts so that students can more easily understand difficult physics concepts. In addition, written learning resources can also help students develop reading and writing skills, which are essential in physics learning [24].

In applying written learning resources in physics learning, teachers need to choose learning resources that suit the needs and characteristics of students. Teachers can choose learning resources that are easy to understand and interesting for students and utilize various kinds of learning media, such as pictures, graphs, and diagrams, to help students understand physics concepts more effectively [25]. Thus, written learning resources in physics learning can be an alternative learning method that is effective in improving student's understanding of physics concepts

b. Exercise questions in the form of scaffolding

Students who expect physics learning on Newton's Law material with practiced problems or scaffolding questions can utilize various types of practice problems tailored to the level of difficulty and ability of students. Scaffolding exercises are designed to assist students in gradually understanding physics concepts, starting from easier problems to more complex levels of difficulty [26]. With this approach, students can build a solid understanding of the physics concepts taught. Practice or scaffolding problems in physics learning can help students develop problem-solving skills and critical thinking [27], [28]. Through practice problems that are designed in a multilevel manner, students can be trained to identify patterns of physics problem-solving and hone their analytical skills [29]. This will help students face challenges in solving physics problems more confidently and effectively.

In applying scaffolding exercises or problems, teachers need to pay attention to the needs and characteristics of students to choose the appropriate type of exercise [30], [31]. By providing challenging but appropriate exercises, teachers can assist students in progressively improving their understanding of physics concepts. In addition, scaffolding exercises or problems can provide a more structured and systematic learning experience for students to develop independent learning skills and improve their academic achievement in physics [32].

2. Observing

a. Video learning media

Observation is an effective tool to help some students learn efficiently and demonstrate better learning outcomes in physics, especially in the chapter on Newton's laws. Students who hope to learn physics on Newton's Laws with video learning media can use various online video content. Physics learning videos can provide clear and interactive visualization of complex physics concepts, helping students understand the principles of Newton's Laws better [33]. With a simple visual display, students can better understand abstract physics concepts.

Using video learning media in physics learning can also increase student involvement in the learning process. Well-designed physics learning videos can enrich students' learning experiences through simulations, visual experiments, and demonstrations of physics concepts that are difficult to understand theoretically [34], [35]. By involving the senses of sight and hearing, video learning media can help students relate physics concepts to real-world situations in a more concrete way

In applying video learning media to physics learning, teachers need to choose relevant video content based on the curriculum and students' level of understanding. By choosing exciting and informative learning videos, teachers can increase students' interest in learning about Newton's Laws material [36]–[40]. Teachers can also use videos to explain physics concepts dynamically and flexibly so that the learning process becomes more interactive and effective for students [15].

b. Demonstration

Students who hope to learn physics on Newton's Laws with demonstrations can take advantage of various physics demonstrations that help students understand physics concepts more visually and visually. Physics demonstrations can provide a clear picture of physics concepts that are difficult to understand theoretically so that students can more easily relate theory to practical applications in everyday life [41]–[43]. By seeing live physics demonstrations, students can better understand abstract physics concepts [43], [44]. Demonstrations in physics learning can also increase student involvement in the learning process [45]. Well-designed physics demonstrations can enrich students' learning experiences through simulations, visual experiments, and demonstrations of physics concepts that are difficult to understand theoretically [43]. By involving the senses of sight and hearing, physics demonstrations can help students relate physics concepts to real-world situations more concretely.

In implementing demonstrations in physics learning, teachers must pay attention to students' needs and characteristics to choose the appropriate type of demonstration. By providing interesting and informative physics demonstrations, teachers can increase students' interest in learning about Newton's Laws [46]. Teachers can also use demonstrations to explain physics concepts dynamically and flexibly so that the learning process becomes more interactive and effective for students [45], [47].

c. Discussion

Students who expect to learn physics on Newton's Laws material with discussions for working on problems or solving problems with teacher guidance can directly interact with teachers and classmates to discuss complex physics concepts. Through discussions, students can share understanding, ideas, and strategies for solving challenging physics problems to improve their understanding of Newton's Law material [48], [49]. Discussions can also help students practice critical and analytical thinking skills in solving physics problems. The use of discussions to work on questions or solve problems in physics learning can also increase student involvement in the learning process. By actively discussing, students can develop communication, collaboration, and problem-solving skills reciprocally with teachers and classmates (Discussions also allow students to ask questions, clarify concepts they have not yet understood, and get direct guidance from the teacher in solving physics problems.

Teachers need to create an inclusive and supportive discussion environment in applying discussions to work on questions or solve problems with teacher guidance. Teachers must provide clear directions, encourage the active participation of all students, and provide constructive feedback during the discussion process [15]. Thus, using discussion as a learning strategy for understanding Newton's Laws material can help students develop a deeper understanding of the social and cognitive skills needed to solve physics problems.

3. Practicum

a. Real phenomenon

Students who expect to learn physics on Newton's Law material through the phenomenon of Newton's Law, which is brought into the classroom, can gain a more real and relevant learning experience. Bringing physics phenomena related to Newton's Laws into the classroom allows students to see firsthand how physics concepts are applied in real-world situations. This can help students link theory with practice so that their understanding of Newton's Laws becomes more concrete and in-depth [43], [50], [51].

Learning with the phenomenon of Newton's Law brought into the classroom can also increase students' interest and motivation in learning physics [43], [52], [53]. Through direct experience with physical phenomena, students can feel the relevance and usefulness of physics concepts in everyday life. This can trigger students' curiosity and motivate them to be more active in learning [53]. Thus, learning through the phenomenon of Newton's Law can create an inspiring and interesting learning environment for students.

In implementing learning using Newton's Law, teachers must prepare learning materials that are interesting and relevant to students' daily lives. Teachers also need to facilitate discussion and reflection about observed phenomena so that students can better understand the physics concepts being taught [54], [55]. With this approach, learning through the phenomenon of Newton's Law not only provides an impressive learning experience for students but also helps them develop critical and analytical thinking skills in understanding physics [56], [57].

b. Practicals and Reports

Students who expect to learn physics based on Newton's Laws with related practicums can gain direct experience in practically observing and testing physics concepts. Through practicum, students can apply Newton's Laws in real experimental situations, deepening their understanding of these concepts. Apart from that, through practicums, students can also develop practical skills such as observation, measurement, and data analysis, which are essential in physics [58], [59].

After carrying out a practicum related to Newton's Law, the most important thing is to make a report and discuss the practicum results. In this process, students are invited to summarize the results of observations, data obtained, and conclusions obtained from the practicum. Through making reports and discussions, students can practice their scientific communication skills and deepen their understanding of the physics concepts they have studied [60], [61].

Making reports and discussing the results of Newton's Law practicum can also help students hone analytical and scientific reasoning skills [62], [63]. Students can train their critical and logical thinking skills by detailing the experimental process, data interpretation, and conclusions obtained. Apart from that, through discussing practicum results with teachers and classmates, students can also broaden their horizons and understanding of the application of Newton's Laws in various contexts [64].

c. Differentiated learning

The variety of ways in which students learn underscores the need for diverse learning strategies, particularly in the context of the physics chapter on Newton's laws. Recognizing and accommodating diverse learning preferences is critical to optimizing student engagement and understanding [65]–[67]. The three main learning modes—reading, observing, and participating in practical activities—must be differentiated to meet the diverse learning styles in the classroom. Different learning styles and preferences among students can lead to varying levels of engagement and understanding of the material [68]–[70]. Educators can meet individual learning styles and preferences by providing various learning options, ultimately improving student learning outcomes.

Providing different learning opportunities in physics education is necessary for each class. The diversity of options in physics education—including reading, observing, and practicum—presents various opportunities and challenges for students and teachers. However, differentiated teaching can support students with different learning preferences [71]. Support and differentiation, such as accommodations, assistive technology, or grouping students according to their readiness, are essential to meet individual student needs in physics education [72], [73].

4. Recommendations for Instructional Design and Curriculum Integration

The findings of this study indicate that students' needs in physics learning, particularly on the topic of Newton's Laws, are diverse. Three main needs were identified: practical-based learning, observational learning, and self-directed learning through written resources. These results highlight that successful physics instruction greatly depends on the teacher's ability to accommodate varied learning styles within the classroom. More specifically, the need for practical and observational learning underscores the importance of active and interactive learning experiences. Students who respond better to hands-on practical methods exhibit a kinesthetic learning style, requiring physical engagement and direct experimentation to grasp abstract concepts like Newton's Laws. On the other hand, students who prefer observational methods often have an audio-visual learning style, indicating that visual media, such as videos and demonstrations, can improve their understanding of complex physics concepts.

a. Recommendations for Enhancing Instructional Design

To effectively integrate these findings into the design of physics instruction, it is recommended that educators implement differentiated learning approaches. This strategy can address individual student needs by offering various learning methods tailored to their preferences, including hands-on activities, observation, and self-guided study. Furthermore, expanding the sample size in future studies, for instance, by involving students from a broader geographic region or across different educational levels, would improve the generalizability of these findings. By incorporating a more diverse student sample, analyses of learning needs related to Newton's Laws could be more representative, providing comprehensive insights for inclusive curriculum design at the national level.

b. Integration in the Physics Curriculum

Incorporating students' learning needs into the design of physics instruction also requires a flexible curriculum that allows educators to adapt instructional methods to the classroom's needs. For instance, project-based or inquiry-based learning approaches could be combined with practical modules to support kinesthetic learners. Meanwhile, digital learning media, such as video simulations and virtual demonstrations, could effectively meet the needs of students with visual learning preferences.

These findings underscore that implementing adaptive learning approaches tailored to students' needs can significantly enhance student motivation and learning outcomes in physics. By integrating these varied instructional approaches, students are expected to gain a deeper understanding of physics concepts and cultivate a more substantial interest in science.

IV. Conclusions

Until now, learning implementation continues to evolve based on policy changes to meet expected outcomes and based on the diversity of students in Indonesia. We investigate that one of the reasons for students' failure to achieve learning goals is that they experience learning differently from what they need or want. So, we investigate the learning needs expected by each student in physics learning, especially in Newton's Law material. This research is limited to the diversity of students at high schools in Malang City and Malang Regency. We found that the needs of high school students are quite diverse, and then we categorized the variation of student learning needs into three types of learning needs with consideration of learning styles. There are three types of learning needs categories: needs in reading, needs in observing, and needs in practicum. All variations of learning needs in reading are categorized in the reading and writing learning style, variations of learning needs in observing are categorized in the audio-visual learning style, and variations of learning needs in practicum are categorized in the kinesthetic learning style. As a recommendation, the results of this study can be applied to develop a more inclusive physics curriculum design. A differentiated learning approach can be used to accommodate diverse learning needs, allowing students to choose the learning methods that are most effective for them. Thus, physics learning will be more meaningful and relevant, improving learning outcomes. There is great hope for every student that if their learning needs are met, it will be easy to achieve learning objectives as stipulated in the policy and curriculum. However, the research that has been carried out is limited to student learning needs in the learning process and learning style reviews; we hope that this research can be continued in deeper areas related to diversity in the implementation of student learning and broader scientific material.

Acknowledgements

We want to thank all participants involved, especially the teachers from City High School and Regency High School, Physics Education supervisors, physics education students, and all student respondents from City High School and Regency High School.

References

[1] S. A. Putri, S. S. S, and E. Oktavianty, “Remediasi Miskonsepsi Siswa Pada Materi Hukum Newton Menggunakan Jigsaw Berbantuan Booklet Kelas VIII SMP,” *Jurnal Pendidikan dan Pembelajaran Khatulistiwa (JPPK)*, vol. 3, no. 1, 2014, doi: 10.26418/jppk.v3i1.4238.

[2] S. Kusairi, .. Sutopo, and A. Suryadi, “Utilizing Isomorphic Multiple-Choice Items to Diagnose Students’ Misconceptions in Force and Motion,” *New Physics: Sae Mulli*, vol. 72, no. 4, pp. 311–318, Apr. 2022, doi: 10.3938/NPSM.72.311.

[3] J. L. Docktor and J. P. Mestre, “Synthesis of discipline-based education research in physics,” *Physical Review Special Topics - Physics Education Research*, vol. 10, no. 2, p. 020119, Sep. 2014, doi: 10.1103/PhysRevSTPER.10.020119.

[4] T. Stelzer, G. Gladding, J. P. Mestre, and D. T. Brookes, “Comparing the efficacy of multimedia modules with traditional textbooks for learning introductory physics content,” *Am J Phys*, vol. 77, no. 2, pp. 184–190, Feb. 2009, doi: 10.1119/1.3028204.

[5] R. Nuriyah, L. Yuliati, and E. Supriana, “Eksplorasi Penguasaan Konsep Menggunakan Experiential Learning pada Materi Hukum Newton,” *Jurnal Pendidikan: Teori, Penelitian, & Pengembangan*, vol. 3, no. 10, pp. 1270–1277, 2018. doi:10.17977/jptpp.v3i10.11608.

[6] A. Maries and C. Singh, “To use or not to use diagrams: The effect of drawing a diagram in solving introductory physics problems,” in *2012 Physics Education Research Conference*, Philadelphia, PA, USA: AIP Publishing, 2013, pp. 282–285. doi: 10.1063/1.4789707.

[7] A. F. Heckler and T. M. Scaife, “Adding and subtracting vectors: The problem with the arrow representation,” *Physical Review Special Topics - Physics Education Research*, vol. 11, no. 1, p. 010101, Jan. 2015, doi: 10.1103/PhysRevSTPER.11.010101.

[8] D.-H. Nguyen and N. S. Rebello, “Students’ Difficulties With Multiple Representations in Introductory Mechanics,” *US-China Education Review A*, vol. 8, no. 5, pp. 559–569, 2011, doi: 10.17265/2161-623X/2011.05A.001.

[9] M. Ishimoto, G. Davenport, and M. C. Wittmann, “Use of item response curves of the Force and Motion Conceptual Evaluation to compare Japanese and American students’ views on force and motion,” *Phys Rev Phys Educ Res*, vol. 13, no. 2, p. 020135, Nov. 2017, doi: 10.1103/PhysRevPhysEducRes.13.020135.

[10] D. Januarifin, P. Parno, and A. Hidayat, “Kesalahan siswa SMA dalam memecahkan masalah pada materi Hukum Newton,” *Momentum: Physics Education Journal*, Apr. 2018, doi: 10.21067/mpej.v1i1.2292.

[11] D. Saepuzaman, A. Samsudin, A. D. Sutrisno, I. Kaniawati, and Yusnim, *Diagnosis Kesulitan-kesulitan Siswa dalam Konsep Gerak dan Gaya (Sebuah Penelitian Survey)*. 2014.

[12] E. Sailau, F. Yanti, and E. Safitri, “Hubungan Motivasi Belajar dengan Hasil Belajar Siswa Kelas VII SMP Negeri Siberut Barat Daya,” *Horizon (NY)*, vol. 1, no. 4, pp. 614–621, Dec. 2021, doi: 10.22202/horizon.v1i4.5294.

[13] R. F. Siregar, “Collaboration and Achievements of Students Motivation in Physics Learning,” *Journal of Learning and Technology in Physics*, vol. 1, no. 2, p. 51, Jan. 2021, doi: 10.24114/jltp.v1i2.12127.

[14] B. Sumintono, “Pembelajaran Sains, Pengembangan Keterampilan Sains dan Sikap Ilmiah Dalam Meningkatkan Kompetensi Guru,” *Al-Bidayah : Jurnal Pendidikan Dasar Islam*, vol. 2, no. 1, Dec. 2018, doi: 10.14421/al-bidayah.v2i1.8988.

[15] J. C. Rubin *et al.*, “Transforming the future of health together: the learning health systems consensus action plan,” *Learn Health Syst*, vol. 2, no. 3, Jul. 2018, doi: 10.1002/lrh2.10055.

[16] J. W. Creswell, *Educational research*. New Delhi: PHI Learning Private Limited, 2011.

[17] V. Zydziunaite, L. Kaminskiene, V. Jurgile, and E. Jezukeviciene, “‘Learning to Learn’ Characteristics in Educational Interactions between Teacher and Student in the Classroom,” *European Journal of Contemporary Education*, vol. 11, no. 1, Mar. 2022, doi: 10.13187/ejced.2022.1.213.

[18] L. Hasanah Lubis, B. Febriani, R. Fitra Yana, A. Azhar, and M. Darajat, “The Use of Learning Media and its Effect on Improving the Quality of Student Learning Outcomes,” *International Journal Of Education, Social Studies, And Management (IJESSM)*, vol. 3, no. 2, pp. 7–14, Jun. 2023, doi: 10.52121/ijessm.v3i2.148.

[19] B. Wei, C. Wang, and L. Tan, “Visual representation of optical content in China’s and Singapore’s junior secondary physics textbooks,” *Phys Rev Phys Educ Res*, vol. 18, no. 2, p. 020138, Nov. 2022, doi: 10.1103/PhysRevPhysEducRes.18.020138.

[20] A. Nuzzaci, “A picture is worth a thousand words: visual thinking between creative thinking and critical thinking in the teaching-learning processes,” *img journal*, vol. 2019, no. 1, 2019, doi: https://doi.org/10.6092/issn.2724-2463/11071.

[21] A. Ursyn, *Knowledge Visualization and Visual Literacy in Science Education*. IGI Global, 2016. doi: 10.4018/978-1-5225-0480-1.

[22] C. Bradley, J. Allred, and M. Zeidan, “Visualizing Physics Questions,” in *Proceedings of The International Conference on Advanced Research in Education*, Acavent, Mar. 2019. doi: 10.33422/educationconf.2019.03.114.

[23] S. R. Adhiyaksa, “Pengembangan Media Pembelajaran Hukum Newton Game Fisika (Gafik) Berbasis Computer Based Learning,” Thesis, Universitas Islam Negeri Ar-Raniry. [Online]. Available: https://repository.ar-raniry.ac.id/id/eprint/26684/

[24] A. A. Putri, M. A. Pisnaji, and H. Ramadhani, “Mengidentifikasi Karakteristik Sikap Toleransi Terhadap Siswa Kelas X di SMAN 7 Batang Hari,” *Integrated Science Education Journal*, vol. 3, no. 2, pp. 62–65, May 2022, doi: 10.37251/isej.v3i2.261.

[25] N. A. Humairah, F. Alibas, and H. Harianti, “Identifikasi Kemampuan Menginterpretasikan Grafik Hukum Newton Kelas X SMAN 1 Tinambung,” *SAINTIFIK*, vol. 3, no. 2, pp. 190–195, Jul. 2017, doi: 10.31605/saintifik.v3i2.170.

[26] R. W. Fajriani, M. Naswir, and H. Harizon, “Pemberian Scaffolding dalam Bahan Belajar Berbasis Masalah untuk Meningkatkan Kemampuan Berpikir Tingkat Tinggi Siswa,” *PENDIPA Journal of Science Education*, vol. 5, no. 1, pp. 108–114, Jan. 2021, doi: 10.33369/pendipa.5.1.108-114.

[27] I. Herdiman, I. F. Nurismadanti, P. Rengganis, and N. Maryani, “Kemampuan Berpikir Kritis Matematik Siswa SMP Pada Materi Lingkaran,” *PRISMA*, vol. 7, no. 1, p. 1, Jun. 2018, doi: 10.35194/jp.v7i1.213.

[28] I. Siregar, D. Darhim, and E. Cahya, “Analisis Kesulitan Siswa SMP Menghadapi Soal Berpikir Kritis dan Kreatif Matematis,” *Symmetry: Pasundan Journal of Research in Mathematics Learning and Education*, Dec. 2018, doi: 10.23969/symmetry.v3i2.1261.

[29] J. Rokhmat, M. Marzuki, W. Wahyudi, and S. D. Putrie, “A Strategy of Scaffolding Development to Increase Students Problem-Solving Abilities: The Case of Physics Learning with Causalitic-Thinking Approach,” *Turkish Journal of Science Education*, vol. 16, no. 4, pp. 569–579, Nov. 2019, doi: 10.36681/tused.2020.8.

[30] X. Ma, X. Jiang, Y. Jia, T. Wu, and Z. Nie, “Research on Scaffolding Instruction Strategies for English Writing Teaching of Rural Junior Middle School Students in China,” *Adv Soc Sci Res J*, vol. 9, no. 3, pp. 320–339, Apr. 2022, doi: 10.14738/assrj.93.12061.

[31] I. Tabak and B. J. Reiser, “Scaffolding,” in *The Cambridge Handbook of the Learning Sciences*, Cambridge University Press, 2022, pp. 53–71. doi: 10.1017/9781108888295.005.

[32] Y. Iqbal, “Penerapan Strategi Pembelajaran Scaffolding pada Materi Penelitian Sosial sebagai Pemecehan Masalah Sosial,” *JURNAL PARADIGMA : Journal of Sociology Research and Education*, vol. 3, no. 2, pp. 74–83, Dec. 2022, doi: 10.53682/jpjsre.v3i2.5486.

[33] J. R. Dandoy Cotino and V. Mallari Mistades, “Use of Blended Learning Approach in Teaching Newton’s Laws of Motion,” in *2021 3rd International Conference on Modern Educational Technology*, New York, NY, USA: ACM, May 2021, pp. 114–119. doi: 10.1145/3468978.3468997.

[34] F. N. Kumala, A. D. Yasa, A. B. H. Jait, and I. Wulandari, “Pengembangan video pembelajaran berbasis eksperimen untuk mengatasi loss-learning dalam pembelajaran IPA siswa sekolah dasar,” *Jurnal Inspirasi Pendidikan*, vol. 13, no. 1, pp. 28–38, Jan. 2023, doi: 10.21067/jip.v13i1.7834.

[35] J. Z. Lam and M. M. Yunus, “Student-Produced Video for Learning: A Systematic Review,” *Journal of Language Teaching and Research*, vol. 14, no. 2, pp. 386–395, Mar. 2023, doi: 10.17507/jltr.1402.14.

[36] F. Violita, A. A. S. Pratiwi, M. R. Sari, N. Juliana, and R. Rohmani, “Pengaruh Pengunaan Media Visual Terhadap Hasil Belajar Siswa pada Mata Pelajaran IPA di Sekolah Dasar: A Systematic Literature Review,” *IJM*, vol. 1, no. 5, 2023, [Online]. Available: https://journal.csspublishing.com/index.php/ijm/article/view/437

[37] L. Ratri Mayarita, D. Dafik, and T. Prastati, “The Development of Environment-Based Visual Media to Enhance Learning Outcomes and Student Motivation in Science Course,” *International Journal of Current Science Research and Review*, vol. 06, no. 07, Jul. 2023, doi: 10.47191/ijcsrr/V6-i7-56.

[38] T. Irawan, T. Dahlan, and F. Fitrianisah, “Analisis Penggunaan Media Video Animasi Terhadap Motivasi Belajar Siswa di Sekolah Dasar,” *Didaktik : Jurnal Ilmiah PGSD STKIP Subang*, vol. 7, no. 01, pp. 212–225, Apr. 2023, doi: 10.36989/didaktik.v7i01.738.

[39] H. Wahda Nia, S. Sudarman, and V. P. Rahayu, “The Effectiveness of Using Video-Based Learning Media on Learning Motivation of Students of Class X SMA Negeri 3 Samarinda,” *Educational Studies: Conference Series*, vol. 2, no. 2, pp. 268–275, Jan. 2023, doi: 10.30872/escs.v2i2.1619.

[40] M. Megawarni, S. W. D. Pomalato, and I. Djakaria, “The effect of math learning video media on math learning outcomes analyzed based on learning motivation,” *World Journal of Advanced Research and Reviews*, vol. 17, no. 2, pp. 162–168, Feb. 2023, doi: 10.30574/wjarr.2023.17.2.0137.

[41] S. Kilde Löfgren, J. Weidow, and J. Enger, “Rolling balls or trapping ions? How students relate models to real-world phenomena in the physics laboratory,” *Sci Educ*, vol. 107, no. 5, pp. 1215–1237, Sep. 2023, doi: 10.1002/sce.21802.

[42] R. H. Nazarian, “A Modified Recipe for Interactive Classroom Demonstrations,” *Phys Teach*, vol. 60, no. 6, pp. 504–507, Sep. 2022, doi: 10.1119/5.0042862.

[43] S. Ozuho, S. Zhadiq, and I. Tharem, “Application of the Demonstration Method to Improve Concept Understanding and Learning Activities of Students in Physics Subjects,” *Journal La Edusci*, vol. 2, no. 3, pp. 22–28, Aug. 2021, doi: 10.37899/journallaedusci.v2i3.400.

[44] S. Y. Ho, “Uncovering the Wealth of Physics Examples from Videos on the Internet for Use in Physics Lessons,” *The Physics Educator*, vol. 02, no. 01, p. 2050005, Mar. 2020, doi: 10.1142/S2661339520500055.

[45] A. Khandelwal *et al.*, “Modern Physics Demonstrations with DIY Smartphone Spectrometers,” *The Physics Educator*, vol. 04, no. 01, Mar. 2022, doi: 10.1142/S2661339522500032.

[46] I. T. Lucz and M. Milner-Bolotin, “Video making as a powerful tool in physics teacher education and in teaching and learning,” *J Phys Conf Ser*, vol. 2297, no. 1, p. 012026, Jun. 2022, doi: 10.1088/1742-6596/2297/1/012026.

[47] K. Özmen, “Integrating physics demonstrations in undergraduate audiology classroom,” *Phys Educ*, vol. 54, no. 6, p. 065020, Nov. 2019, doi: 10.1088/1361-6552/ab4567.

[48] Ellianawati, D. Rudiana, J. Sabandar, and B. Subali, “Focus group discussion in mathematical physics learning,” *J Phys Conf Ser*, vol. 983, p. 012010, Mar. 2018, doi: 10.1088/1742-6596/983/1/012010.

[49] C. M. Carbonaro, A. Zurru, V. Fanti, M. Tuveri, and G. Usai, “Cooperative Problem Solving: an experience of high-school teaching updating,” *arXiv preprint arXiv:2003.07731*, Mar. 2020, doi: 10.48550/arXiv.2003.07731.

[50] B. Awudi and S. Danso, “Improving students’ performance and conceptual understanding of heat transfer using demonstration method,” *Journal of Mathematics and Science Teacher*, vol. 3, no. 2, p. em037, Jul. 2023, doi: 10.29333/mathsciteacher/13164.

[51] D. Samitra, M. L. Firdaus, and Y. Krisnawati, “Physics Education Technology Project (PhET): Interactive Simulation to Improve Students’ Understanding of Concepts and Perceptions,” *Jurnal Paedagogy*, vol. 10, no. 3, p. 646, Jul. 2023, doi: 10.33394/jp.v10i3.7879.

[52] H. J. Banda and J. Nzabahimana, “The Impact of Physics Education Technology (PhET) Interactive Simulation-Based Learning on Motivation and Academic Achievement Among Malawian Physics Students,” *J Sci Educ Technol*, vol. 32, no. 1, pp. 127–141, Feb. 2023, doi: 10.1007/s10956-022-10010-3.

[53] A. Triyanto, I. Istiqomah, and T. A. Arigiyati, “The Learning Process with Contextual Approach to Improve Students’ Motivation and Mathematics Learning Achievement,” *Journal of Instructional Mathematics*, vol. 3, no. 1, pp. 26–35, May 2022, doi: 10.37640/jim.v3i1.1043.

[54] E. H. Eshuis, J. ter Vrugte, and T. de Jong, “Supporting reflection to improve learning from self-generated concept maps,” *Metacogn Learn*, vol. 17, no. 3, pp. 691–713, Dec. 2022, doi: 10.1007/s11409-022-09299-7.

[55] G. Andrea, V. Chris, B. Wageeh, J. Dhammika, M. Lisa, and P. Marie, “Using reflective writing and textual explanations to evaluate students’ conceptual knowledge,” in *Proceedings of the 26th Annual Conference of the Australasian Association for Engineering Education (AAEE2015)*, Australia: School of Engineering, Deakin University, 2015, pp. 1–10.

[56] N. W. Agustin, Sarwanto, and A. Supriyanto, “Enhancement of critical thinking skill in physics through experimental method: Is it effective?,” 2023, p. 090003. doi: 10.1063/5.0105703.

[57] Yetri, Koderi, Amirudin, S. Latifah, and M. D. Apriliana, “The Effectiveness of Physics Demonstration Kit: The Effect on The Science Process Skills Through Students’ Critical Thinking,” *J Phys Conf Ser*, vol. 1155, p. 012061, Feb. 2019, doi: 10.1088/1742-6596/1155/1/012061.

[58] Y. B. Bhakti, R. A. Sumarni, S. Mayanty, and I. A. D. Astuti, “Developing Virtual Physics Practicum Module of Optic Based on Guided Inquiry to Improve Students’ Science Process Skills,” *Journal of Science and Science Education*, vol. 4, no. 1, pp. 39–49, Apr. 2023, doi: 10.29303/jossed.v4i1.2329.

[59] P. Deswita, M. Suari, and A. A. Zamista, “Development of Electrical Measuring Instruments Practicum Modules Based on Science Process Skills for Physics Students,” *Sainstek : Jurnal Sains dan Teknologi*, vol. 15, no. 1, p. 53, Jun. 2023, doi: 10.31958/js.v15i1.9293.

[60] Y. Sari, R. Qadar, and A. Hakim, “Analysis of High School Students’ Conceptual Understanding of Physics on Temperature and Heat Concepts,” *International Journal of STEM Education for Sustainability*, vol. 3, no. 1, pp. 212–224, Jan. 2023, doi: 10.53889/ijses.v3i1.92.

[61] A. H. Panuluh, “Improving the science process skills of physics education students by using guided inquiry practicum,” Nov. 2022, [Online]. Available: http://arxiv.org/abs/2211.04006

[62] A. Basid and R. Rusli, “Improve Scientific Abilities Students Through Model Development Testing Experiments,” *Jurnal Neutrino*, vol. 11, no. 1, p. 32, Sep. 2018, doi: 10.18860/neu.v11i1.8833.

[63] R. P. Purnama, R. A. Denya, P. Pitriana, S. Andhika, M. D. D. Setia, and E. Nurfadillah, “Developing HOT-LAB-Based Physics Practicum E-Module to improve Practicing critical thinking skills,” *Journal of Science Education Research*, vol. 5, no. 2, pp. 43–49, Oct. 2021, doi: 10.21831/jser.v5i2.41904.

[64] R. Amelia, R. S. N. Azizah, A. R. Suwandi, I. F. Amalia, and A. Ismail, “Application of Augmented Reality to Physics Practicum to Enchane Students’ Understanding of Concepts,” *International Journal Of Scientific & Technology Research*, vol. 9, no. 3, pp. 1128–1131, 2020.

[65] C. Gan, J. Yang, R. Zhou, and C. Shen, “Online Learning with Diverse User Preferences,” in *2019 IEEE International Symposium on Information Theory (ISIT)*, IEEE, Jul. 2019, pp. 2539–2543. doi: 10.1109/ISIT.2019.8849646.

[66] P. D. Petroff and S. Bush, “Optimizing Student Engagement in a Virtual Environment,” in *Handbook of Research on Lessons Learned From Transitioning to Virtual Classrooms During a Pandemic*, IGI Global, 2021, pp. 344–357. doi: 10.4018/978-1-7998-6557-5.ch019.

[67] A. M. Rogerson and L. C. Rossetto, “Accommodating Student Diversity and Different Learning Backgrounds,” *J Intercult Commun Res*, pp. 1–10, May 2018, doi: 10.1080/17475759.2018.1475293.

[68] N. Sukma, L. Dj, and L. Ranty, “Analysis of Concept Understanding in Material Colligative Properties of Solutions in View of the Tendency of Student Learning Styles at SMA N 1 Gunung Talang,” *Journal of Educational Sciences*, vol. 7, no. 2, p. 314, Apr. 2023, doi: 10.31258/jes.7.2.p.314-323.

[69] B. P. Permatasari and A. D. Sulistyaningtyas, “Analysis of The Ability Student of SMA Al Islam Krian to Understanding Mathematical Concepts in Terms of Learning Styles,” *Journal of Education and Learning Mathematics Research (JELMaR)*, vol. 4, no. 1, pp. 63–69, Jun. 2023, doi: 10.37303/jelmar.v4i1.104.

[70] N. K. Devy *et al.*, “Analysis of Understanding Physics Concepts in terms of Students’ Learning Styles and Thinking Styles,” *Jurnal Penelitian Pendidikan IPA*, vol. 8, no. 4, pp. 2231–2237, Oct. 2022, doi: 10.29303/jppipa.v8i4.1926.

[71] M. P. Kurniawati, A. Mustakim, and M. N. Hudha, “Peningkatan Motivasi dan Hasil Belajar Fisika Dengan Penggunaan Teknologi Dalam Pembelajaran dan Pendekatan Berdiferensiasi Pada Peserta Didik Kelas X – 1 SMA Negeri 6 Kediri Tahun Pelajaran 2022/2023,” *Jurnal Pembelajaran, Bimbingan, dan Pengelolaan Pendidikan*, vol. 3, no. 6, pp. 484–499, Jun. 2023, doi: 10.17977/um065v3i62023p484-499.

[72] K. Amalia, I. Rasyad, and A. Gunawan, “Pembelajaran Berdiferensiasi sebagai Inovasi pembelajaran,” *Journal Of Education And Teaching Learning (JETL)*, vol. 5, no. 2, pp. 185–193, Jul. 2023, doi: 10.51178/jetl.v5i2.1351.

[73] J. P. Yengkopiong, “Differentiation in the Classroom: A Pedagogical Approach for a Successful Engagement of Students in Secondary Schools,” *East African Journal of Education Studies*, vol. 6, no. 2, pp. 9–24, May 2023, doi: 10.37284/eajes.6.2.1213.