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THE EFFECT OF ONLINE DISCOVERY-INQUIRY LEARNING ON IMPROVING CRITICAL THINKING ABILITY AND CONCEPT MASTERY IN TEMPERATURE AND HEAT MATERIALS

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ABSTRACT

The research endeavors to investigate the impact of implementing discovery-inquiry learning concerning the topic of temperature and heat on the enhancement of students' critical thinking abilities and concept mastery. The study adopted a quasi-experimental design, employing a pretest-posttest control group framework. A cluster random sampling technique was applied to select the research sample, which comprised 36 students from class XI MIPA 3 (control group) and class XI MIPA 4 (experimental group) at SMA Negeri Rambipuji. The assessment instruments employed were two essay-shaped tests, specifically designed for evaluating critical thinking ability and concept mastery. Data analysis involved the utilization of independent sample t-test and effect size test. The results revealed a statistically significant improvement in students' critical thinking ability and concept mastery with a robust effect size, categorizing the impact of discovery-inquiry learning as substantial. Consequently, it can be inferred that discovery-inquiry learning is efficacious in augmenting students' critical thinking abilities and concept mastery pertaining to the subject of temperature and heat.

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INTRODUCTION

In the era of digitalization, proficiency in logical reasoning, problem-solving, and decision-making based on empirical evidence is imperative. These cognitive faculties collectively fall within the purview of higher-order thinking. The cultivation of critical thinking skills is essential for adeptly identifying and evaluating data, determining its applicability in drawing conclusions or making decisions related to a phenomenon (Holmes et al., 2015). Consequently, the capacity for critical thinking assumes paramount significance for individuals immersed in scientific endeavors and students within educational institutions. In the context of intensified global competition, it is imperative to equip students with skills for effective communication, collaboration, creativity, innovation, critical thinking, and adept problem-solving. This aligns with scholarly investigations affirming the pivotal role of fostering critical thinking abilities in the pedagogical process (Huber & Kuncel, 2016). Structuring the teaching and learning milieu to afford students opportunities for honing their critical thinking skills emerges as a strategic approach, as underscored by research emphasizing the centrality of developing critical thinking prowess in education (Puspitasari et al., 2017).

The cultivation of critical thinking proficiency constitutes a pivotal objective in the context of physics education, representing a subset of cognitive abilities targeted for enhancement in students (Yeritia et al., 2017). Critical thinking skills serve as the fundamental underpinning of the entire learning process (Heong et al., 2011). Through the application of critical thinking, students can refine their intellectual capacities and aptitudes, enabling them to make discerning choices, formulate compelling conclusions, and sharpen their cognitive acuity.

However, the development of higher-order thinking skills, including critical thinking, poses a considerable challenge. Current impediments to fostering critical thinking abilities include the prevalent use of traditional teaching methodologies, such as didactic lectures delivered by teachers (Fatmawati et al., 2014). Despite teachers' attempts to engage students through questioning and assignments, these endeavors seem to fall short in eliciting active participation and stimulating the advancement of critical thinking skills. Consequently, students often exhibit suboptimal proficiency in critical thinking, and a proclivity toward passivity may manifest due to the monotonous nature of the learning process (Widura et al., 2015).

In response to these challenges, it is imperative to adopt suitable teaching approaches to optimize the cultivation of critical thinking ability in educational settings. The incorporation of effective methodologies will not only enhance the efficiency of the learning process but also contribute significantly to the augmentation of students' critical thinking skills (Widura et al., 2015).

The impartation of concept mastery by teachers to students stands as a crucial pedagogical endeavor. Concept mastery assumes a pivotal role in the adept resolution of problems, particularly when novel concepts are intricately interlinked with pre-existing ones, facilitating meaningful learning experiences. In the realm of physics education, the attainment of concept mastery emerges as a paramount research concern, as elucidated by Yadaeni et al. (2018).

Challenges in the learning process may manifest when students exhibit deficiencies in concept mastery, with low proficiency posing a potential barrier. A noteworthy contributor to learning impediments is the diminished interest of students in the educational proceedings, especially within the domain of physics. The lack of enthusiasm for physics learning can substantially impede the optimization of the learning process. To surmount these challenges, a pivotal strategy involves elevating students' mastery of concepts. This strategic intervention is predicated on the understanding that enhanced concept mastery not only lends meaning to the learning experience but also addresses the fundamental issue of low interest (Kruatong et al., 2006).

Recognizing that robust concept mastery is intrinsic to the augmentation of students' comprehension of physics concepts, the broadening of such mastery is envisaged as a catalyst for the progressive development of students' knowledge. It follows that a comprehensive and expansive grasp of concepts is indispensable for fostering a profound and enduring understanding of physics among students.

Evidently, the cultivation of critical thinking skills and the mastery of concepts among students stand as integral objectives in the realm of physics education. According to Che (2002), it is imperative to hone thinking abilities and enhance concept mastery to facilitate the development of more refined and nuanced ideas among students. This assertion aligns with research findings that underscore the correlation between a deficiency in critical thinking skills and impediments in mastering concepts (Utami et al., 2014).

In the pursuit of concurrently augmenting critical thinking ability and concept mastery, the adoption of specific learning models plays a pivotal role. The discovery-inquiry learning model emerges as a notable approach in this regard. Recognized for its efficacy, this model encourages active student involvement through the exploration of various concepts and principles inherent in the subject matter (Tiarina, 2012). The essence of discovery-inquiry learning lies in placing students at the focal point of the learning process, fostering motivation, empowerment, and active engagement to unlock their potential and creativity (Rahmawatiet al., 2014; Rusilowati, 2013; Wenning & Vieyra, 2020).

This pedagogical model aligns seamlessly with the dynamics of physics learning, particularly in the educational milieu that encourages students to be proactive participants in the learning process. The discovery-inquiry learning model stands out as an apt method, considering its emphasis on student-focused teaching strategies. Within this model, learning activities are designed to prioritize critical and analytical thinking, encouraging students to actively seek and devise solutions to problems. Moreover, the discovery-inquiry learning approach is purposefully structured to mitigate common misconceptions among students and enhance their academic achievement (Suryawan et al., 2020). Therefore, the adoption of the discovery-inquiry learning model emerges as a strategic choice for optimizing the intertwined development of critical thinking skills and concept mastery in physics education.

The conventional face-to-face teaching model has been disrupted by the global COVID-19 pandemic, necessitating a shift to online learning. This transition has presented challenges, as students grapple with difficulties, fatigue, and boredom in adapting to the altered learning environment. With social activities limited, the efficacy of online learning has been questioned, prompting the need for teachers to design strategies that preserve effectiveness while minimizing the burdens on students' independence and thinking skills (Aji, 2020).

In response to these challenges, teachers are encouraged to introduce innovations in online learning to make it more engaging and meaningful. Strategies such as incorporating games (Lay & Osman, 2018; Ichsan et al., 2020), utilizing learning media (Lee, 2016), and employing interesting learning strategies/models (Ichsan et al., 2020) can enhance the online learning experience. The benefits of online learning include providing students with the flexibility to learn independently and access information without direct teacher interaction, complementing traditional classroom learning (Anggraini, 2017).

However, challenges persist, as reported by a physics teacher at SMA Negeri Rambipuji. Virtual meetings through platforms like Zoom or Google Meet were deemed less effective due to factors such as limited student data packages and time constraints. Moreover, the predominant use of lecture methods and assignments in the online learning process has been insufficient for an optimal learning experience. To address these issues, the implementation of the discovery-inquiry learning model in an online format has been proposed. This approach aims to enable students to engage in experimental activities and discussions, thereby enhancing the effectiveness of online physics learning in the current educational landscape.

The study of temperature and heat emerges as a pertinent physics topic conducive to fostering students' critical thinking abilities and concept mastery. The effective learning of this material necessitates active student involvement in exploring information through experiences and discussions, thereby enhancing their comprehension of the subject matter. Given the numerous real-world applications associated with temperature and heat, students can readily identify and construct knowledge from their daily experiences. The versatility of this material also allows for diverse instructional methods, with a particular emphasis on packaging it in experimental activities.

The research endeavors to address existing weaknesses in the learning process, particularly in the context of online education, where the conventional methods may fall short. By employing the discovery-inquiry method, the study aims to optimize online learning on temperature and heat, with the overarching goal of enhancing students' critical thinking skills and concept mastery. While the application of the discovery-inquiry method in online learning about temperature and heat is relatively underexplored in current research literature, it holds substantial potential for elevating the quality of student learning experiences.

The novelty of incorporating the discovery-inquiry method in the online learning environment is underscored by its capacity to engage students actively, fostering a deeper understanding of temperature and heat phenomena. Through this research, it is anticipated that the method will present instrumental in overcoming challenges associated with online learning and contribute significantly to the enhancement of students' critical thinking skills and concept mastery in the topic of temperature and heat physics.

METHOD

This research adopts a quasi-experimental design with a quantitative research approach. The cluster random sampling technique is employed for sample selection, drawing participants from two distinct groups. The first group comprises students from class XI MIPA 3 and serves as the control group, while the second group consists of students from class XI MIPA 4 and functions as the experimental group. The study is conducted among XI MIPA class students at SMA Negeri Rambipuji, who are the research subjects.

The research methodology is anchored in the pretest-posttest control group design, following the scheme proposed by Creswell (2012), as outlined in Figure 1. This design facilitates a systematic investigation into the impact of the discovery-inquiry method on online learning about temperature and heat. The utilization of control and experimental groups enables a comparative analysis of the outcomes, providing insights into the effectiveness of the instructional approach. The research design aligns with established methodologies to ensure rigor and reliability in evaluating the improvement of students' critical thinking skills and concept mastery in the context of physics education.

The research employed two types of test instruments: a critical thinking ability test, consisting of 10 essay questions, and a concept mastery test, comprising 8 essay questions. The evaluation of critical thinking ability utilized six indicators, namely interpretation, analysis, evaluation, inference, expansion, and self-regulation, as proposed by Facione (2015). For the concept mastery test, assessment was carried out using the cognitive domain levels C1–C5.

Before integration into the research, both instruments underwent a trial stage involving 100 students who had previously studied the material. The trial results revealed a high reliability value of 0.82 for the critical thinking ability instrument and 0.78 for the concept mastery instrument. This signifies the instruments' suitability for use in the research context. Furthermore, the research instruments, encompassing 9 questions on critical thinking ability and 7 questions on concept mastery, have been deemed valid based on the trial results. This validation ensures the credibility and appropriateness of the instruments in effectively measuring the targeted constructs within the study.

This study involved two distinct groups of students undergoing physics education with the implementation of two different learning approaches. The experimental group engaged in physics learning through the application of the discovery-inquiry method, while the control group experienced physics learning via the direct learning method. The discovery-inquiry process unfolded across the following stages, i.e. (1) stimulation, (2) problem identification, (3) data collection, (4) data processing, (5) proof, and (6) conclusion.

Upon collecting the research data, the subsequent phase involves analysis utilizing the independent sample t-test method. This analytical approach is complemented by an effect size test to ascertain the magnitude of the influence of discovery-inquiry learning in enhancing students' critical thinking ability and concept mastery, specifically in the context of the temperature and heat material.

Before embarking on the independent sample t-test and effect size test, a prerequisite test was conducted. This preliminary assessment ensures the fulfillment of essential statistical assumptions, contributing to the robustness and validity of the subsequent analyses. The careful adherence to these methodological steps enhances the reliability of the findings and strengthens the overall rigor of the research investigation.

RESULTS

In Table 1, a normality test was conducted to ensure that the data related to critical thinking ability and concept mastery in both groups adhered to a normal distribution. The significance level chosen for this test was 0.05, and the results indicated that both sets of data were normally distributed. Subsequently, Table 2 presents the outcomes of a homogeneity test, which aimed to identify significant differences in variances between the groups for critical thinking ability and concept mastery. With a significance level of 0.05, the results revealed no substantial differences in the variances between the groups. Following these prerequisite tests, an independent sample t-test was performed (Table 3) to compare posttest scores of critical thinking ability and concept mastery between the two groups. The significant level of 0.000 (< 0.05) indicated a noteworthy difference in scores between the groups.

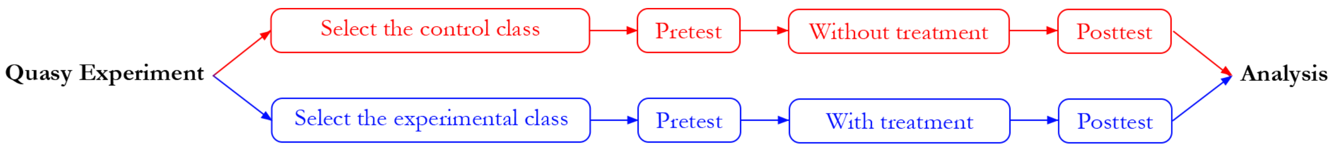

Figure 1. Research design of pretest-posttest quasy experiment.

Table 1. Normality test result.

Capability	Group	Shapiro-Wilk		
		Statistic	df	Sig.
Critical thinking ability	Experimental pretest	0.942	36	0.060
	Experimental posttest	0.959	36	0.205
	Control pretest	0.942	36	0.060
	Control posttest	0.945	36	0.074
Concept mastery	Experimental pretest	0.942	36	0.060
	Experimental posttest	0.949	36	0.098
	Control pretest	0.943	36	0.065
	Control posttest	0.945	36	0.070

Table 2. Homogenity test result.

Capability	Based On	Levence Statistic	df1	df2	Sig.
Critical thinking ability	Mean	1.103	3	140	0.350
Concept mastery	Mean	0.296	3	140	0.828

Table 3. Independent sample t-test result of posttest for experimental and control groups.

Capability	Statistics	Value	Category
Critical thinking ability	Sig. (2-tailed)	0.000	Significant difference
Concept mastery	Sig. (2-tailed)	0.000	Significant difference

Table 4. Effect size test result for experimental and control groups.

Capability	Group	Value	Category
Critical thinking ability	Experimental	7.62	Strong effect
	Control	0.95	Moderat effect
Concept mastery	Experimental	5.93	Strong effect
	Control	0.92	Moderat effect

Lastly, Table 4 displays the results of an effect size test, showcasing that the experimental group, utilizing a discovery-inquiry learning approach, exhibited a strong influence on improving critical thinking ability and concept mastery (effect size values of 7.62 and 5.93, respectively). In contrast, the control group, employing a direct learning model, demonstrated a medium influence on both critical thinking ability and concept mastery, with effect size values of 0.95 and 0.92.

DISCUSSION

The comprehensive analysis of students' critical thinking ability in both the experimental and control groups, both before and after treatment, through statistical techniques reveals noteworthy improvements. With a cohort of 36 students in each class, those exposed to discovery-inquiry learning exhibited higher critical thinking ability compared to their counterparts undergoing direct online learning, as depicted in Table 4. The research findings substantiate the effectiveness of discovery-inquiry learning in enhancing critical thinking skills and concept mastery relative to direct learning, corroborating the outcomes of prior studies, such as Huda et al. (2018), which assert the superiority of inquiry-discovery learning over conventional approaches.

The efficacy of the discovery-inquiry learning model in fostering critical thinking ability can be attributed to the deliberate design of the online learning process, aimed at motivating students to engage with the material on temperature and heat. Reinforcement comes in the form of in-depth supplementary materials, including learning videos and electronically delivered Learning Kits (e-LKPD), specifically designed to support the development of critical thinking skills and concept mastery indicators. Practical experiments further augment the learning experience, aiding students in grasping concepts and honing their thinking skills. This aligns with the research by Thaiposri and Wannapiroon (2015), which highlights the appropriateness of inquiry learning in real-world practicums, facilitating problem-solving and skill development.

The discovery-inquiry learning stages, involving real-world problems, contribute significantly to the training of critical thinking ability and concept mastery. This is affirmed by Akinoğlu and Tandoğan (2007), who emphasize the impact of practical problem-solving on students' critical thinking abilities and deeper conceptual understanding. The ability to solve problems is intrinsically linked to a solid grasp of fundamental concepts, as underscored by Keleş and Özsoy (2009).

The transformative impact of discovery-inquiry learning on students' critical thinking ability and concept mastery is further validated by changes in conceptual knowledge observed in posttests. The lower pretest scores, possibly indicative of prior reliance on lecture-based learning, witness a significant increase after the application of the discovery-inquiry model. This shift not only highlights the effectiveness of the model in enhancing critical thinking ability and concept mastery but also underscores the potential benefits of online implementation, providing broader access to information compared to direct learning.

In conclusion, the inquiry-discovery learning model, particularly when adapted for online delivery, emerges as a potent tool for improving students' critical thinking ability and concept mastery in physics education. The positive impact observed in this study aligns with previous research, emphasizing the pivotal role of inquiry-discovery learning in cultivating higher-order thinking skills and meaningful conceptual understanding among students.

CONCLUSION

In summary, the research findings unequivocally establish the effectiveness of the discovery-inquiry learning model when applied to the temperature and heat material, resulting in a significant enhancement of both critical thinking ability and concept mastery among students. The robust effect size outcomes, registering at 7.62 for critical thinking ability and 5.93 for concept mastery, fall within the strong effect category. These results affirm the substantial positive impact of the discovery-inquiry learning model on students' cognitive and conceptual development in the context of physics education. The success observed in this study positions the discovery-inquiry learning model as a viable pedagogical approach for various learning materials. The strong effect size values underscore the model's potency in fostering critical thinking skills and deepening conceptual understanding, serving as a noteworthy reference for future studies seeking to elevate student learning outcomes through the implementation of this effective learning model.

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AUTHOR CONTRIBUTIONS

All authors contributed to the conception and design of the study, data collection, analyze, interpretation, writing, and revision of the manuscript. All authors approved the final version of the manuscript.

CONFLICT OF INTEREST STATEMENT

Regarding the research, writing, and publication of this paper, the authors state they have no competing interests.

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