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Hybrid discovery learning: Solutions for optimizing students' critical thinking and ICT skills on temperature fluctuations material

Sudi Dul Aji[a], Hena Dian Ayu[a]*, Mila Rosita[b], Cholisina Anik Prawira[c]

[a]Universitas PGRI Kanjuruhan Malang, S. Supriadi St., No.48, Malang, East Java, 65148, Indonesia
[b]Sekolah Menengah Atas Dharma Wanita 01 Bululawang Malang, Bakalan St., No. 120, Malang, East Java, 65171, Indonesia
[c]National Central University, No. 300, Zhongda Rd., Zhongli District, Taoyuan City, 320317, Taiwan
e-mail: henadianayu@unikama.ac.id
* Corresponding Author.

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Abstract: This research aims to optimize the critical thinking skills and information communication technology (ICT skills) of students regarding temperature fluctuations material through the implementation of a hybrid discovery learning method. The hybrid discovery learning method provides the efficacy and efficiency of the physics learning process at three Malang Junior High Schools. The type of research used was quasi-experimental with a post-test only group design. There were 143 students enrolled in this research, divided into six study groups. The experimental class consisted of 74 students, while the control class comprised 69 students. The data were collected using a multiple-choice test instrument that evaluated critical thinking skills at the cognitive level. The experimental group achieved an average score of 71.1, while the control group achieved 60.1. Furthermore, data pertaining to ICT skill was gathered through the utilization of observation sheet and questionnaires during the learning process. The Wilk's Lambda in the Manova test gave results of Sig. (0,000) < (0,05). This demonstrates that the hybrid discovery learning model influences students' critical thinking and ICT skills. Therefore, the implementation of the hybrid discovery learning to temperature fluctuations material can optimize the learning process on the critical thinking and ICT skills.
Keywords: hybrid discovery learning; critical thinking skills; ICT skills

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Introduction

Natural science education consists of the investigation and explanation of natural phenomena, which becomes the advancement of technology from physics study (Syahmel & Jumadi, 2019). Physics learning consists of process, attitude, and product (Koretsky, Kelly, & Gummer, 2011). The Ministry of Education and Culture has reported that the score on science subjects at the junior high school level on national exams is still low with the average of 49.43. The percentage for physics subjects at the senior high school level is 46.47. This is because students hold the perception that physics content consists solely of formulas, data sets, and ontological assumptions which are abstract (Ding, 2019; Jatmiko, Prahani, & Munasir, 2018). Teachers can surmount this issue by providing students with a meaningful learning process and experiences that have an impact on their thinking process of analyzing, constructing, and utilizing information communication technology (Ayu et al., 2021; Hammer, 1997; Mayer, 2004b). Discovery learning is one of the learning models recommended by the Ministry of Education and Culture (Putri, Roza, & Maimunah, 2020).

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The discovery learning is a context-based learning that imparts immediate knowledge and requires students to independently identify a theory or concept, so they must participate actively in the process (Bruner, 1961; Mayer, 2004a). The discovery learning model typically comprises multiple groups and prior knowledge, and students are capable of resolving a problem using their newly acquired knowledge and experience (Abdisa & Getinet, 2012; Jong & Joolingen, 2007). Students are more likely to be good at retaining information that is acquired through the discovery learning process, as it involves direct investigation of problems and requires them to apply their own understanding (Nkambou, Fournier-viger, & Mephu, 2011; Wahyudi & Rukmini, 2019; Yuliani & Saragih, 2015). Technology integration is an absolute necessity in the twenty-first century. Hybrid learning is one approach that aligns with the attributes of the learning model of the twenty-first century (Colley & Guéry, 2015; Nakano & Wechsler, 2018; Wu, Kim, & Markauskaite, 2020). This approach integrates both online and offline learning in order to enhance the quality of education. The positive involvement of hybrid learning to the twenty-first century skills has also been demonstrated by a number of studies (Mahmudah, 2019; Rorimpandey & Midun, 2021; Tsai, 2011).

Hybrid learning necessitates the incorporation of technology into the learning process. Consequently, it will significantly impact the ICT skills (Kardkarnklai, 2015). Students are expected to possess a range of competencies as part of the learning revolution 4.0 educational paradigm. These competencies include knowledge and resource literacy, problem definition, analytical thinking, group problem solving, critical thinking, and effective communication (Ayu, Saputro, Sarwanto, & Mulyani, 2023; Saputra, Joyoatmojo, & Wardani, 2019). Furthermore, in the era of revolution 4.0, an online learning has emerged due to Covid-19 pandemic, affecting a limited number of institutions that have managed to implement online learning successfully amidst the crisis. Consequently, the efficacy of the learning process is also contingent upon the implementation of face-to-face learning. In line with the advancements in science and technology and the requirements of the education paradigm of the 4.0 revolution, it is possible to incorporate the discovery learning to the hybrid learning. By combining cognitive, behavioristic, and constructive learning, hybrid learning is a learning mode conducted through the application of technology that optimizes learning outcomes (Abdulhak, Djohar, & Wahyudin, 2018; Ora, Sahatcija, & Ferhataj, 2018). Hybrid discovery learning is more effective and efficient, as well as can foster the development of critical thinking and ICT skills. This is due to its ability to accommodate flexible learning styles with respect to time and location. Moreover, it can prove advantageous during a pandemic that necessitates online learning, such as during Covid-19 pandemic (Jong & Joolingen, 2007; Ora et al., 2018; Sothayapetch & Lavonen, 2022).

Critical thinking is an idea or speculation to discover information with the intention of gaining a more profound comprehension. Furthermore, critical thinking is a form of logical thinking that necessitates the capacity to assess and identify an issue (Mclean, 2005; Pratiwi et al., 2021). Critical thinking involves evaluating and analyzing in order to enhance a thought. Objective outcomes of self-regulatory of critical thinking include conclusions, conceptual explanations, logic, interpretation, reviews, and contextual considerations based on judgment (Cáceres, Nussbaum, & Ortiz, 2020; Facione, 2011; Utami, Saputro, Ashadi, & Masykuri, 2017). In addition to critical thinking, mastery of ICT skills is also crucial. The possession of ICT skills is an essential requirement for the successful execution of hybrid discovery learning. A study demonstrates that technology-assisted learning contributes to elements of constructivism and observational learning, permits independent investigation of experiments and knowledge, and broadens students' knowledge beyond the classroom (Jufriadi, Ayu, & Pratiwi, 2019; Kumar, 2021). A number of studies have been undertaken to enhance ICT skills and critical thinking through the integration of hybrid learning models and approaches (Ataie, Evangelinou, & Gianniti, 2021; Carrió, Larramona, & Baños, 2011; Lian & He, 2013; Liang, 2021; O'Connell & Lang, 2018). Nevertheless, the integration of hybrid learning and discovery learning with respect to junior high school students' ICT skills and critical thinking is the subject of relatively few studies. Prior studies have thus far been implemented with regard to high school and university students. The integration of electronic media into hybrid discovery learning has the potential to enhance the learning process's efficacy and efficiency (Yusuf & Koeshandayanto, 2018). Consequently, the objective of this research is to determine how to optimize hybrid discovery learning method in order to enhance students' ICT skills

and critical thinking skills regarding temperature fluctuations materials (Yusuf & Koeshandayanto, 2018).

Method

This research was carried out at three public junior high schools in Malang utilizing a quasi-experimental design. The criteria for selecting junior high schools were A and B accreditation scores for both public and private institutions. This research employed a posttest only group design, as illustrated in Table 1. All students enrolled in three public junior high schools in Malang comprised the study population. The sampling method used was a cluster random sampling. On the basis of the processing and analysis of the ICT skills questionnaire and the critical thinking instrument consisting of forty reasoned multiple-choice questions, it has been determined that seventeen questions were invalid and 23 questions satisfied the valid criteria. Therefore, the invalid questions were omitted. In addition, sixteen of twenty-three valid questions of the instrument were modified to assess critical thinking skills for the purposes of research. The research utilized the ICT skills questionnaire instrument, which comprised 25 statements, all of which satisfied the valid criteria and were utilized to assess ICT-skills. The Manova test is employed for data analysis, with the assistance of SPSS for Windows 16.0. Prior to employing Manova for hypothesis testing, two prerequisite tests were conducted: tests for normality and homogeneity. The purpose of the analysis technique was to ascertain how the learning process for students' ICT skills and critical thinking could be optimized.

The critical thinking indicators utilized in this research are predicated on those suggested by Facione: (1) interpreting; (2) analyzing; (3) inference; (4) evaluation; (5) explanation; and (6) self-regulation (Hajhosseiny, 2012). In this research, the following competencies were assessed as indicators of ICT skills: (1) defining; (2) accessing; (3) managing; (4) integrating; (5) evaluating; (6) creating; and (7) communicating (Katz, 2014).

Table 1.Research Design

Independent Variable / Dependent Variable	Model	
	Hybrid Discovery Learning (A_1)	Discovery Learning (A_2)
ICT skills (B_1)	A_1B_1	A_2B_1
Critical thinking (B_2)	A_1B_2	A_2B_2

Note:
A_1B_1: ICT skills of experiment class through hybrid discovery learning
A_2B_1: ICT skills of control class through discovery learning
A_1B_2: Critical thinking skills of experiment class through hybrid discovery learning
A_2B_2: Critical thinking skills of control class through discovery learning

Results and Discussion

The students of control group engaged in discovery learning, whereas the experimental group utilized a hybrid discovery learning. The duration of this research was three meetings. The outcomes of the assessments of critical thinking and ICT skills are presented in Tables 2, 3, and 4. On the basis of the data regarding ICT skills and critical thinking, the experimental class has a higher average score than the control group.

Table 2. Critical Thinking Skills Score of the Students

Group	Learning Model	Sample	Critical Thinking Score		Average
			Highest	Lowest	
Experiment	Hybrid discovery learning	74	96	42	71.1
Control	Discovery learning	69	88	20	60.1

Table 3. ICT skills Questionnaire Scores of the Students

Group	Learning Model	Sample	ICT Skills Score		Average
			Highest	Lowest	
Experiment	Hybrid discovery learning	74	92	64	81.9
Control	Discovery learning	69	84	56	72.8

Table 4. ICT skills Observation Sheet Scores of the Students

Group	Learning Model	Sample	ICT Skills Score		Average
			Highest	Lowest	
Experiment	Hybrid discovery learning	74	100	55.5	80.3
Control	Discovery learning	69	94.4	50	72.2

The necessary data analysis was conducted based on the results of the data regarding the value of critical thinking and ICT skills. The results of the normality test indicate that the control class' significance value for the ICT-skills questionnaire is 0.200, significance value for ICT-skills observation sheet is 0.069, and significance value for critical thinking skills is 0.097. The experimental class's normality test reveals that the ICT-skills questionnaire has a significance value of 0.189, the ICT-skills observation sheet has a significance value of 0.137, and critical thinking skills has a significance value of 0.065. In contrast, the results of the homogeneous test indicate that the ICT-skills questionnaire has a significance value of 0.134, the ICT-skills observation sheet has a significance value of 0.534, and critical thinking skills have a significance value of 0.097. The data are concluded to be normally distributed and homogeneous on the basis of these results. Based on the outcomes of the Manova analysis, it is evident that the significance value of the procedure test for all four tests is 0.000. This indicates that the hybrid discovery learning model does indeed have an impact on students' critical thinking and ICT skills. The variations in each variable are presented in Table 5.

Table 5. The Result of Individual Variable on Effect Analysis

Source	Dependent Variable	df	Sig.
Class	ICT-skills Questionnaires	1	.000
	LO ICT-skills	1	.038
	Critical thinking	1	.006

The significance value of the Manova test is 0,000, indicating that the hybrid discovery learning model has an impact on both critical thinking and ICT skills. Although the results of analyzing individual variables are presented in Table 5, the significance value for each variable is less than 0.05, indicating that there is a distinction between them. Consequently, the hybrid discovery learning method can optimize the learning process with regard to temperature fluctuations material.

The hybrid discovery learning positively influences the social development, which is also more engaging, effective, and yields higher outcomes than discovery learning alone (Rojas-Drummond, Torreblanca, Pedraza, Vélez, & Guzmán, 2013). As a result, classroom learning is more efficient (Nkambou et al., 2011). The hybrid application enhances critical thinking skills substantially. The data presented in Figure 1 is a graph of the results of students' skills assessments.

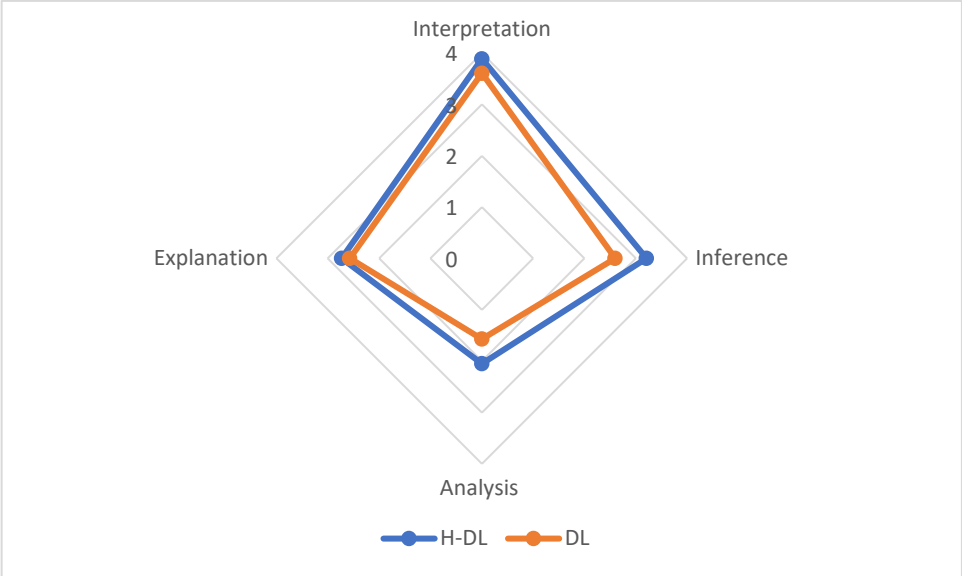

Figure 1. The Results of Students' Critical Thinking Skills

The average score obtained through hybrid discovery learning appears to be higher than that obtained through discovery learning, as shown in Figure 1. This distinction is due to the two phases of the employed learning model. Students are encouraged to explore during the stimulation phase of hybrid discovery learning, which may result in problem-solving activities (Carvalho, Fiuza, & Conboy, 2015). Therefore, during the stimulation portion of hybrid discovery learning, students are encouraged to identify and deduce a particular concept or statement (Jong & Joolingen, 2007). In contrast, during the discovery learning phase, students are not required to independently discover a concept; rather, the teacher imparts information (Abdisa & Getinet, 2012). The hybrid discovery learning model involves students engaging with instructional videos and completing teacher-assigned online questions via Schoology. This approach serves to enhance students' ICT skills and critical thinking skills (Jufriadi & Andinisari, 2020). By virtue of being able to access information through technological means, students also possess the autonomy to select and oversee instructional materials, schedules, locations, and other essential learning resources. Additionally, students have the ability to engage in online discussions in order to seek clarification on any unclear information or concepts. In contrast to the discovery learning model, where students are solely reliant on references to learning resources, the control class does not permit the use of technology for information literacy purposes. This is due to the fact that all learning occurs within the confines of the classroom and school environment (Cydis, 2015; Pamuk, 2012).

Indicators of interpretation demonstrate to students their capacity to comprehend and articulate significance, including that of experiences, data, and events. The interpretation indicator manifests itself in the following stages of hybrid discovery learning: stimulation, data collection, processing, and generating. The students' interpretation aspects are based on their capacity to respond to interpretation questions that require critical thinking skills, such as identifying the conditions under which gas expansion takes place and calculating the coefficient of volumetric expansion of a gas. There are 79% of students in the experimental class who achieved the highest possible grade, whereas only 57% of students in the control class did so.

The inference indicator is present in the phase of hybrid discovery learning comprising stimulation, problem statement, verification, and generation. The inference indicator requires students to draw conclusions, generate hypotheses, and evaluate pertinent information obtained from concepts, data, principles, statements, and inquiries (Heidari & Ebrahimi, 2016; Park, Kim, Kim, & Yoo, 2012). The evaluation of students' inference skills is conducted through their responses to inference items that assess critical thinking skills. Specifically, students are required to convert a temperature scale from Celsius which is 40^{o}C to Fahrenheit. Variations in responses of exploration results can be observed among the experimental class s when it comes to converting the temperature scale in accordance with

the prescribed sequence of known, inquired, and formulaic questions. In contrast, the control class solely generated the ultimate solution. It is evident that the experimental group gives greater concern to relevant information.

Students demonstrate the ability to identify inferential connections among statements, queries, concepts, and descriptions through the analysis indicator. During the phase of hybrid discovery learning, analysis indicators are generated through stimulation, problem statement, collected data, and data processing. Students are able to identify and analyze a problem as part of the analysis indicator, in addition to exploring it (Dhina, Hadisoebroto, & Mubaroq, 2019). The evaluation of students' analysis aspect is determined by their ability to respond to critical thinking skills analysis items, specifically identifying and concluding a statement regarding the quantity of liquid that was spilled in the glass due to the expansion. The subsequent responses are those of experimental class participants who have discerned that both the liquid and glass undergo expansion.The explanation indicator is present during the generation phase of hybrid discovery learning, where students are required to articulate and provide justifications for their thinking, in addition to drawing conclusions (Facione, 2011; Ghadampour & Keshtiaray, 2013). The students' explanation aspect is evident in their responses to the explanation questions pertaining to critical thinking skills. Students are capable of communicating the outcomes of their logical deductions concerning the procedure for shattering three metal parts. The response of students who obtained the highest possible grade in the experimental class is as follows.

The discovery learning model also incorporates the four Facione's indicators. Nevertheless, the discovery learning model entails a substantial investment of time in the learning process and provides students with a comparatively limited number of learning reference sources than the hybrid discovery learning model (Clark, 2015). Thus, students receive information without independently discovering any concepts or principles. Additionally, ICT skills can be enhanced and impacted by hybrid discovery learning (Yusuf & Koeshandayanto, 2018). The graphs depicting the outcomes of student ICT skills data are presented in Figure 2 and Figure 3.

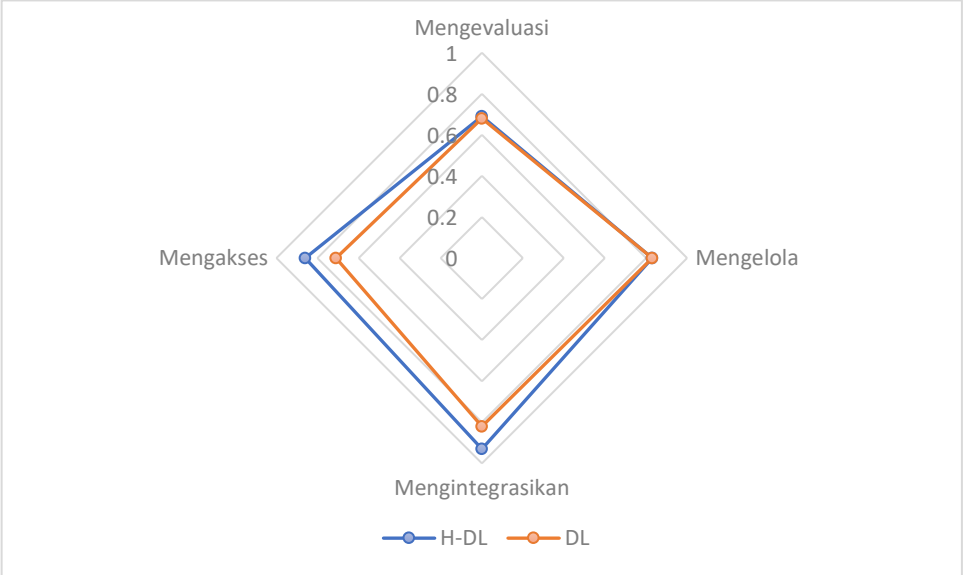

Figure 2. ICT skills Observation Sheet Score of the Students

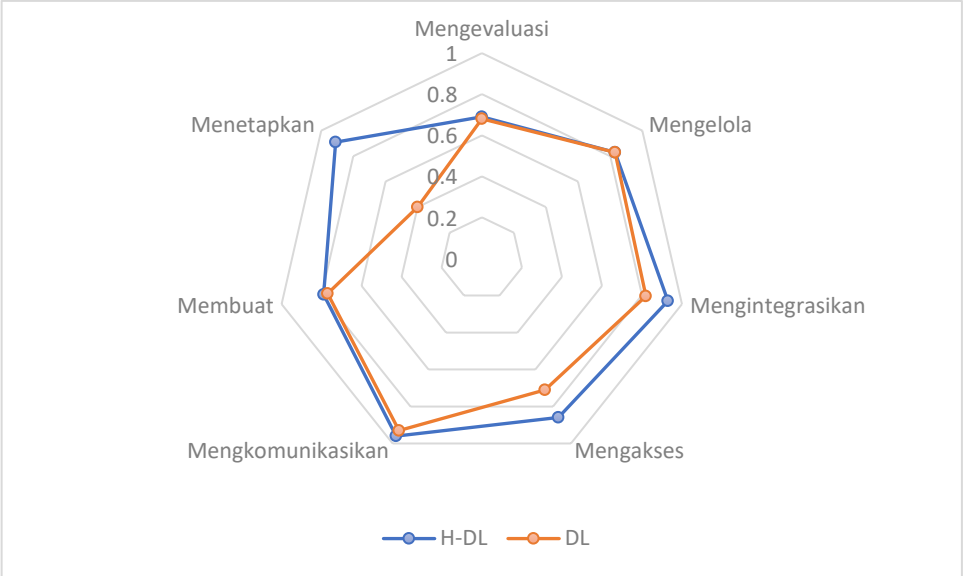

Figure 3. ICT skills Questionnaire Score of the Students

The ICT skills indicators that may be incorporated during the stimulation phase of hybrid discovery learning are defining, accessing, generating, and communicating. In a digital environment, students possess the capability to recognize, gather, utilize, and communicate information (Crawford & Jenkins, 2017; Patmanthara & Hidayat, 2018). The ICT skills indicators that may be incorporated during the problem statement phase of hybrid discovery learning are defining, creating, and integrating. In this phase, the students are capable of integrating and applying the identified information (Nantha, Pimdee, & Sitthiworachart, 2022). The ICT skills indicators that may be incorporated during collecting data phase of hybrid discovery learning are accessing and managing. During this phase, students acquire information through the utilization of digital or technological means. During the data processing phase of hybrid discovery learning, ICT-skills indicators are defining and managing. Students are capable of processing information during this phase. The indicator of the verification and generation phase of hybrid discovery learning is communicating. During this phase, the students possess the capability to communicate statements and information in a digital format (Yusuf & Koeshandayanto, 2018).

Conclusion

It is possible to conclude, on the basis of the conducted research, that students' critical thinking and ICT skills regarding temperature and fluctuations can be optimized through the implementation of the hybrid discovery learning method. The impact of this research on students' ICT-skills and critical thinking skills is supported by the significance value of 0,000 < 0,05 obtained from the Manova test. Additionally, critical thinking and ICT skills vary between hybrid discovery learning and traditional discovery learning. This study provides further support for the notion that it is feasible to implement any learning model in a hybrid mode, provided that it is backed by the appropriate technology.

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