Effectiveness of Guided Inquiry Learning Model on Thermodynamics Content in LMS-Based Blended Learning with Regard to Students' Higher Order Thinking Skills

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Abstract: The purpose of this study is to evaluate the impact of blended learning utilizing a learning management system (LMS) on students' higher order thinking skills when applied to thermodynamics content. Students from classes XI MIPA 1 and XI MIPA 2 at SMA N 1 Sumberejo in Tanggamus Regency during the academic year 2022/2023 served as the study's samples. The control group pretest-posttest study design was employed with description questions served as the research tool. Blended learning that is based on an LMS and employs the guided inquiry learning model can help students' higher order thinking skills, as shown by the experimental class's average N-gain average of 0.7456, This is more than the medium-level average N-gain of 0.5878 for the control class. This demonstrates that experimental class students are better at higher order thinking than control class students. Additionally, evidence from the Independent Sample T-Test Hypothesis Test supports it, with a sig. (2-tailed) of 0.000, showing that blended learning using a learning management system and a guided inquiry learning model on content related to thermodynamics effectively improves students' higher order thinking abilities. The C4 (analyze) indication has shown the most improvement in higher order thinking abilities.

Keywords: Blended learning; Guide inquiry; Higher order thinking skills; LMS

Introduction

The 21st century learning paradigm, which includes changes in curriculum, media, and technology, is very popular in bringing rapid changes to the growth of science and technology, learning paradigms, in particular, educational modifications, media, and technology. Students must have critical thinking skills, the ability to use information, Regarding the role of digital literacy in 21st century education, especially in the 2013 curriculum. In order for these demands to be implemented, teachers and students are required to be literate in digital technology.

In fact, based on the results of interviews with physics teachers at SMA N 1 Sumberejo, Tanggamus Regency on August 19, 2022. Learning in the classroom has not been loaded with 21st Century skills, for

example in class XI SMA N 1 Sumberejo, physics learning carried out still uses a teacher-centered learning strategy (teacher centered learning) with the lecture method especially Thermodynamics material. Lecture learning certainly does not give students the experience to show the facts of a theory (Basuki et al., 2015). In addition, based on the results of the PISA test conducted in 2018, the average score of Indonesian students in science subjects is still lower than that of OECD (Organization for Economic Cooperation and Development) countries (Kemendikbud, 2019).

In accordance with the demands of learning in the 21st century, learning physics requires developing critical thinking skills to understand concepts and understand how to use them in problem solving. The 21st century learning paradigm must be able to produce a number of skills, such as students' ability to think

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critically, connect knowledge with the real world, master information technology, communicate and work together (Anggraeni et al., 2020). To do this, it is very important to adjust the initial idea to the actual situation, which can be done by developing thinking skills. Thinking skills are divided into two parts, namely low-order thinking skills (LOTS) and high-order thinking skills (HOTS) (Anggraini et al., 2019). Higher Order Thinking Skills (HOTS) is the ability of students to understand knowledge that is not only educational in linking facts owned at a higher level of thinking to be able to evaluate and produce a concept (Widyastuti, 2017).

The use of learning models that are not in accordance with the subject matter being taught is also one of the problems that contribute to students' low understanding of the basic ideas of physics. Most teachers in this modern era still conduct learning by using the lecture method and teacher-centered learning. So that many students have the assumption that the learning is not meaningful, because the learning is monotonous and has nothing to do with events that occur in real life around them (Chan et al., 2021). To help students understand concepts better, an efficient learning model is needed.

The learning models applied in schools are relatively many, but those that are suitable for teaching scientific reasoning skills are not all models are appropriate. Searching from many sources, especially from research results that have been published in reputable journals, has shown that the guided inquiry learning model is considered effective to improve students' reasoning skills (Yulianti et al., 2020). According to the guided inquiry learning paradigm, a teacher can help students understand a subject by providing examples from the subject (Eggen et al., 2012). During the learning process, the teacher assists students in problem solving and solution discovery independently. Although the guided inquiry learning style has benefits to increase students' motivation and help students face challenges, one of the drawbacks is that it requires more time, especially when learning information about thermodynamics. Therefore, a blended learning approach can be incorporated into the learning solution to increase its effectiveness.

In this new ultra-smart society, everything will be connected through technology and all technologies will be integrated, dramatically improving the quality of life. Industrial Revolution 4.0 is a strategic initiative introduced by the German government with the aim of transforming the manufacturing industry through digitization and exploitation of new technologies. Therefore, in terms of learning, educators need to understand technological developments and changes in learning methods along with the advances in technology that are currently developing (Gultom et al., 2021). Blended learning is teaching by combining online and offline (face-to-face) learning with social interaction (Arifin et al., 2021).

In the blended learning method, the process of digesting information occurs formally and informally. In addition to the learning process being guided by teachers in face-to-face and online, students' knowledge can also be accompanied by utilizing technology and media available through the internet (Dari et al., 2022). In blended learning, using a learning management system is not enough without good planning. The roles that are arranged must still be able to increase student activeness in learning. Student activeness in online learning can be seen from student responses and activities. Student response and activity can be seen in student interaction because it plays an important role in online learning (Qamarya et al., 2023). This blended learning can be implemented by using blended learning model, namely station-rotation model. This blended learning model combines three stations or places, namely online learning through LMS, offline learning under the direction of the teacher, and offline learning together in groups (Horn et al., 2012).

Previous research has shown the effect of blended learning. For example, research by Akhmalia et al. (2018) Since the average N-gain value in the experimental class is higher than the average N-gain in the control class (0.84>0.70), it can be seen that blended learning using LMS and inquiry-based learning strategies can improve students' conceptual understanding of static fluid information. However, to succeed in 21st century learning, students must be able to use information, have critical thinking and problem-solving skills, and be digitally literate. This study aims to determine the effectiveness of blended learning using learning management system and guided inquiry learning model on thermodynamics content in terms of students' higher order thinking skills.

Method

This research method is quantitative using post-test control group design. The population of this study amounted to 3 classes totaling 108 students of grade 11 SMA Negeri 1 Sumberjo. The sample was taken by purposive sampling, class XI MIPA 2 became the experimental class (36 students) and class XI MIPA 1 became the control class (36 students).

Students in the experimental class received LMS-based blended learning using guided inquiry learning model, while the control class received LMS-based blended learning using conventional learning model

(lecture and discussion method). The blended learning model in this study uses station-rotation model and uses LMS Canvas. This research refers to Basic Competencies 3.7 Analyze changes in ideal gas by applying the Laws of Thermodynamics and 4.7 Make works/models of the application of laws I and II of Thermodynamics and their physical meaning. The higher-order thinking skills instrument is in the form of an essay to measure the ability to analyze (C4) and evaluate (C5) (Anderson et al., 2010).

To ascertain whether students' higher order thinking skills had improved after the therapy, the N-gain test was used. Furthermore, for hypothesis testing using normality test with Kolmogorov-Smirnov non-parametric statistical test, homogeneity test, independent sample t-Test and effect size test. The independent sample t-Test test used the N-gain test from the control class and the experimental class.

Result and Discussion

According to Anderson et al. (2010), the assessment tool contained 10 items of description questions covering Thermodynamics content that fell within the categories of higher order thinking abilities, namely C4 (analyze) and C5 (evaluate). Table 1 displays the item distribution and item analysis.

Table 1. Distribution of HOTS Test Items and Item Analysis

HOTS Indicator	Question Item	Class					
		Experiment					Control
		Pre-test	Post-test	Difference	Pre-test	Post-test	Difference
C4 (analyze)	5 6 7 9 10	38. 11	94. 91	56. 8	29. 39	76. 98	47. 59
C5 (evaluate)	1 2 3 4 8	33. 14	72. 73	39. 59	35. 46	64. 36	28. 9

According to the analysis findings, indicator C4 (analyzing) showed the greatest improvement in higher order thinking skills, having a greater developmental difference of 56.8 vs. 47.59 between the experimental and control classes. Based on the item analysis in Table 1, the experimental class experienced a large increase in the C4 (analyzing) indicator. High-level thinking skills, according to Widyaastuti (2017), explain how to connect the knowledge possessed with a higher level of thinking so that it can produce an idea. High Order Thinking Skills (HOTS) is defined as the process of transferring from a problem to a solution using critical thinking (Hidayatullah et al., 2022). In question number 10, students are able to analyze the total heat of a refrigerator that has a certain power and temperature so that they can determine the result which is the total heat of the refrigerator by using the carnot refrigeration engine equation. This is an example of increasing the indicator on C4 (analyzing). Since during blended learning, students actively participated in online discussions on the LMS canvas, enthusiastically conducted group experiments, and were very active during face-to-face learning by asking questions and discussing with each other, the C4 (analyzing) indicator has increased.

When compared to the C4 (analyze) indicator, the indicator of higher order thinking skills at C5 (evaluate) shows a smaller increase. The experimental class experienced an increase of 39.59 percent more than the control class which experienced an increase of 28.1 percent. Students have high-level thinking skills, in accordance with the opinion of Abubakar et al. (Abubakar et al., 2021), if they can use logic and analysis to find solutions to problems. HOTS increase when students are able to design experiments, conduct experiments, and analyze results (compare, evaluate, and revise), they can practice analysis, evaluation, and creating skills and train creativity (Hadiati et al., 2023). The reason for the low improvement in this indicator is because not all students have the ability to identify, assess, and connect information about a subject, solve problems, and draw valid conclusions. Students can analyze problem statements regarding a person's behavior in relation to the idea of thermal equilibrium at indication C5 (evaluate). They can assess the truth of the statement. The following is an illustration of student answers on indicator C5 (evaluate) in Figure 1.
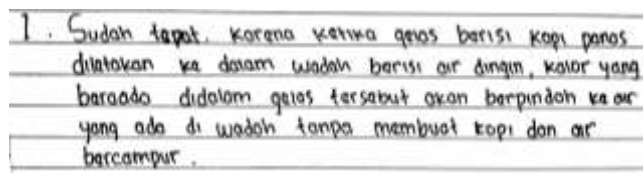

Figure 1. Example of student answers on indicator c5 (evaluate)

Based on the example of student answers on indicator C5, students can be said to be able to judge if students can analyze problems accurately, understand the meaning of statements, and provide appropriate reasons or evidence (Mariani et al., 2021). Students must explain the accuracy of the actions of someone who puts a glass of hot coffee into a container of cold water using the concept of thermal equilibrium material in the Zero Law of Thermodynamics, especially if two objects are in the same state of motion. In Figure 1, the student's

answer only discusses the accuracy of the action taken by someone against the statement in the problem and has not yet come to evaluate and connect it with the material concepts that have been learned. The lack of basic knowledge and direct experience to solve daily problems in the learning process is also the cause of the low efforts in organizing education to achieve HOTS (Jihannita et al., 2023).

The results of the average N-gain also indicate an improvement in learning outcomes. According to this research, student learning outcomes in experimental and control classes from pretests and posttests are used to measure students' starting abilities and end abilities based on higher order thinking capabilities. Table 2 displays the average N-gain statistics.

Table 2. Average N-gain Data

Class				Score
	Highest N-gain	Lowest N-gain	Average N-gain	Category
Experiment	0.91	0.47	0.7456	High
Control	0.81	0.39	0.5878	Medium

The N-gain data in Table 2 for students' higher order thinking ability shows that when LMS-based blended learning with guided inquiry learning model is used, the experimental class which is in the high category has an increase of 0.7456, while the control class which is in the medium category has an increase of 0.5878. The data in this study were normally distributed and had the same variance, so the independent sample t-Test test was used to assess the research data followed by the N-gain test to determine whether the control class and experimental class had different N-gain values. Because the results of the independent sample t-Test test show that the sig (2-tailed) value is smaller than 0.05, H0 is rejected and H1 is accepted. The choice confirmed the hypothesis because there was a significant difference in the average N-gain score at the 95% confidence level between the experimental and control classes. The results of this study also show that guided inquiry learning with LMS provides a considerable influence on the development of students' higher order thinking skills, with an effect size value of 1.150.

This LMS-based blended learning uses a blended learning paradigm with a guided inquiry learning method. Blended learning allows students to interact with each other in the form of discussions and information obtained from various sources continuously so that higher-order thinking skills, especially students' critical thinking skills, can be developed (Doyan et al., 2022). Three learning activities - online learning using LMS canvas, offline group learning, and offline learning under teacher guidance - are included in this blended learning paradigm. Learning will alternate between the

three learning activities. Students are taught to play an active role in the learning process and understand as much as possible about the subject matter being discussed in order to be able to answer questions about the phenomena posed in the discussion forum. To proceed to the next level, information seeking activities are included in online learning before offline learning. Figure 2 is an illustration of online learning activities.
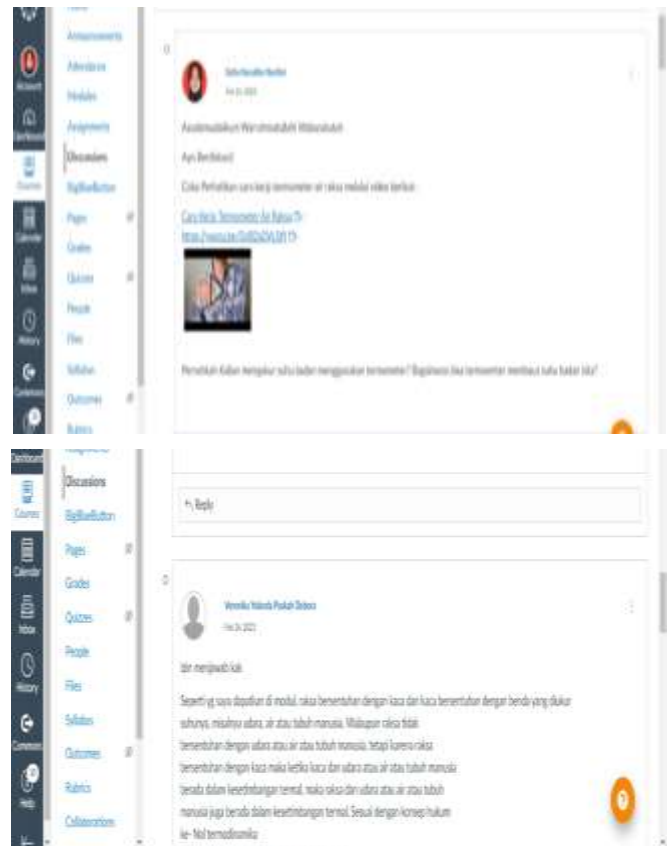

Figure 2. Online learning activities

Students are taught to examine (C4) the connection between the operation of a mercury thermometer and the thermal equilibrium process described by the Zero Law of Thermodynamics based on online learning. The glass is in contact with the object being measured, even though the mercury is not, and because of this contact with the glass, the object being measured is in thermal equilibrium. At this point, students are able to analyze how the thermometer functions. Students are competent to evaluate because they can comprehend and come up with innovative, critical answers to challenges (Nugroho, 2018).

Learning activities in the experimental class used LMS-based blended learning with guided inquiry learning model according to Llewellyn et al. (2013). The learning phases of LMS-based blended learning with guided inquiry learning model in the experimental class can be seen in Table 3.

Table 3. Phase of Blended Learning with Guided Guided Inquiry Learning Model

Blended Learning Stage	Syntax of Guide Inquiry Learning Model	Learning Activities
Online Learning	Investigating a Phenomenon	The instructor teaches students to discover answers to issues in the phenomena given in the discussion forum on LMS Canvas and helps them examine the relationship of a phenomenon.
	Focusing on the Question	The teacher directs students to answer questions from a phenomenon. And to make hypotheses based on the phenomenon.
	Planning the Investigation	The teacher guides students to observe the video given in the discussion forum. And directs students to look for experimental tools and materials available around the student worksheet
Offline learning (group activity)	Planning the Investigation	The teacher guides students to design an experiment with the tools and materials that have been analyzed in the online meeting with the instructions provided in the student worksheet.
	Analyzing Data and Evidence	The teacher directs students to conduct experiments in groups using tools and materials according to the experimental steps on the student worksheet.
Offline learning under the Direction of the teacher	Analyzing Data and Evidence	The teacher guides the students to present and analyze the data and evidence from the experiment. and direct students to make conclusions from the results of the experiment according to the steps on the student worksheet.
	Building New Knowledge	Students must be able to make a tenuous connection between what they already know and the new knowledge they have learned as a result of doing experiments. The teacher helps students assess their degree of conceptual comprehension through the use of concept reinforcement questions. The fresh knowledge they have gained through the trial.
	Communicating New Knowledge	The teacher directs students to make conclusions from the learning. And also conduct presentations to provide arguments and direct discussions to conclude the learning outcomes.

The stage of examining data and evidence of experimental findings on Law I of Thermodynamics, which can be shown in Figure 3, is where higher order thinking skill indications may be observed increasing.

Based on the example of student worksheet answers, students with their groups are trained to be able to analyze (C4) data and evidence of the results of their experiments on the Law I of Thermodynamics. According to Rosnawati (2009), when students successfully solve problems, it means that they have learned new, more complex rules that encourage students to think at a higher level (High Order Thinking Skills). The balloon in the bottle can expand after being treated by being placed in boiling water, which indicates that the system gets heat from the environment to cause the balloon to expand. The findings of the Law I Thermodynamics experiment using this balloon are now available for students to assess.

Another reason the higher order thinking skills indicator develops with LMS-based blended learning using guided inquiry learning strategy is the use of technology, namely LMS Canvas for learning activities so that it can support learning and is adaptive. LMS functions as an important catalog, registration, and approval, running and monitoring learning, evaluation, communication, reports, training plans, and as integration in learning (Syafei et al., 2022). Canvas LMS can help teachers in providing material and carrying out the learning process, canvas is one of the blended learning media that has many features (Nurjati et al., 2021). One of the features used in this study is a discussion forum through modules, assignment and grade features and many other features that are very suitable for blended learning.

Blended learning can result in a more productive and successful learning environment (Abdullah, 2018). In blended learning, teachers can create their own learning media (content production) so that it is easier to help students during learning activities (Handoko et al., 2018). The combination of media in this online learning will be a means for students and teachers, learning media as a means to deliver material so that it can

appropriately achieve learning objectives, according to Susanti (2022). Blended learning will offer the greatest benefits to students in online learning. Additionally, blended learning makes it simpler for students to undertake learning conditioning since they can easily access the same subject matter online. Thus, it is plausible to assert that guided inquiry learning with a blended learning LMS design can enhance students' higher order thinking abilities. Additionally, the limitations of the guided inquiry approach, notably time constraints, can be solved via blended learning employing the guided inquiry learning paradigm. This is due to the need for teacher guidance when identifying a problem to generate new knowledge captured by students.

Figure 3. Example of student worksheet learner answers

The instructor assists students in identifying conceptual problem solving during the investigation so that they can find a solution to the problem. With the help of this guided inquiry learning strategy, students are engaged in real-world issues and directed to conduct investigations. Guided inquiry learning limits the instructor's role as a source of information, the instructor does not tell the concepts but guides students to find these concepts through learning activities, so that the concepts obtained based on these learning activities and experiences will always be remembered by students for a long time (Nurmayani et al., 2018). The emphasis in guided inquiry learning is on students' ability to think critically and analytically so that they can find their own answers (Sanjaya, 2010). The guided inquiry learning paradigm can improve students' critical thinking skills, in accordance with the research of Wulandari et al. (2022), with an N-gain value of 0.61 in the medium

category. The benefit of this guided inquiry learning technique is that the teacher can direct student participation in activities by asking open-ended questions and encouraging discussion.

Additionally, Dewanda et al. (2022) did almost identical studies in the past addressing how guided inquiry learning based on blended learning might enhance student learning results for the subject related to gas kinetic theory. The average score on the experimental class posttest, which was 92, and the paired sample t-test hypothesis test, which had a sig value of 0.000, both support this. Other research was conducted by Sugita et al. (2022) regarding the guided inquiry model based on blended learning is effective for improving student learning outcomes, with an N-gain value of 0.78 in the high category and other research conducted by Akhmalia et al. (2018) regarding LMS-based blended learning with an inquiry learning model on static fluid material is effective for improving student concept mastery with an N-gain value of 0.84 in the high category. Based on relevant research, it shows that blended learning has a relatively similar N-gain score with other studies. The close N-gain range is due to the small average prestest score, it can be caused by the low level of initial knowledge of the students, and the high average posttest score.

The findings indicated that the experimental class, which had previously engaged in less physics learning activities, had increased their participation. Marked by students actively discussing in the discussion forum on courses canvas, through group learning by completing student worksheet and making observations, and active and enthusiastic in offline learning to find new knowledge. According to the connectivism learning theory, teachers can use social media in the classroom to improve and disseminate knowledge more quickly, as well as to use a variety of learning resources and encourage students to use the internet to find reliable, scientific information that will help them learn new things (Bell, 2009).

According to this research's benefits, students can use different media as learning resources, learn in advance to understand the concept of material wherever blended learning with the station-rotation model, and by using this guided inquiry learning model, students can more easily identify, understand, and solve problems. Students can also learn to use various media as learning resources.

By incorporating each level of the guided inquiry learning model with the station-rotation paradigm in blended learning, learning may be made more significant, important, and dense. LMS-based blended learning is improving students' higher order thinking abilities on thermodynamics material in class XI MIPA 2

as an experimental class by using the guided inquiry learning model as an external factor that affects cognitive learning outcomes, even though the results are not yet perfect and students are still being observed at every stage of learning.

Conclusion

Guided inquiry learning using LMS is beneficial to improve students' higher order thinking skills on thermodynamic material. This can be seen from the difference in the average N-gain of the experimental class (N-gain = 0.7456) using LMS-based blended learning with guided inquiry learning model is higher than the control class (N-gain = 0.5878) using LMS-based blended learning with conventional learning model. For HOTS indicator C4 (analyze) showed the highest growth of higher order thinking skills, but indicator C5 (evaluate) still needs development.

Conflicts of Interests
The authors declare no conflict of interest.

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