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Cybernetic Theory in Improving Students' Higher Order Thinking Skill

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ABSTRAK

Pesatnya perkembangan pengetahuan dan teknologi di era abad 21, pendidikan menjadi hal yang sangat penting dalam menghadapi tantangan global. Peserta didik dituntuk untuk memiliki keterampilan berpikir tingkat tinggi. Pendidikan berperan penting dalam membentuk HOTS peserta didik dalam menghadapi tantangan di era saat ini. Tujuan penelitian ini untuk menganalisis pengaruh penerapan teori sibernetik terhadap HOTS. Jenis penelitian ini yaitu quasi experiment dengan desain non equivalent control group design. Populasi penelitian ini adalah peserta didik kelas IV SD yang berjumlah 42 peserta didik. Sampel penelitian ini adalah kelas IV A sebanyak 20 peserta didik dan kelas IV B sebanyak 22 peserta didik. Kelas IV A merupakan kelas eksperimen yang melakukan pembelajaran dengan teori sibernetik, sedangkan kelas IV B sebagai kelas kontrol yang melakukan pembelajaran konvensional. Metode dalam pengumpulan data adalah observasi, wawancara, dan tes. Instrumen yang digunakan dalam pengumpulan data adalah lembar observasi, lembar wawancara, dan tes pilihan ganda. Data dianalisis dengan deskriptif kuantitatif dan t-test independent sampling. Hasil uji-t yang telah dilakukan diperoleh nilai thitung sebesar 9,645 dengan ttabel 1,684. Hal tersebut mengartikan bahwa thitung > ttabel sehingga Ha diterima dan Ho ditolak. Sehingga dapat disimpulkan ada pengaruh yang signifikan penerapan teori sibernetik terhadap HOTS peserta didik kelas IV SD. Oleh karena itu penggunaan teori sibernetik dapat menjadi pendekatan yang efektif dalam mengembangkan HOTS pada tingkat SD.

ABSTRACT

The rapid development of knowledge and technology in the 21st century era, education is very important in facing global challenges. Students are required to have higher order thinking skills. Education plays an important role in shaping students' HOTS in facing challenges in the current era. The purpose of this study was to analyze the effect of implementing cybernetic theory on HOTS. This type of research is a quasi-experimental design with a non-equivalent control group design. The population of this study were fourth grade elementary school students, totalling 42 students. The sample of this research was class IV A with 20 students and class IV B with 22 students. Class IV A is an experimental class that does learning with cybernetic theory, while class IV B is a control class that does conventional learning. Methods in data collection are interviews and tests. The instruments used in data collection were interview sheets and multiple-choice tests. Data were analyzed with quantitative descriptive and independent sampling t test. The results of the t-test that have been carried out obtained a t-count value of 9.645 with a t-table of 1.684. This means that t-count > t-table so that Ha is accepted and Ho is rejected. So, it can be concluded that there is a significant effect of the application of cybernetic theory on the HOTS of fourth grade elementary school students. Therefore, the use of cybernetic theory can be an effective approach in developing HOTS at the elementary school.

1. INTRODUCTION

The development of knowledge and technology in the 21st century towards the current Society 5.0 era makes all activities use technology (Rahmansyah et al., 2021; Saraswati & Agustika, 2020; Telaumbanua et al., 2022). This means that the rapid development of knowledge and technology cannot be avoided, but

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must be faced and mastered (Hamdani et al., 2022; Nofia Henita & Desyandri, 2023). Human resources are required to excel and be of high quality by mastering 21st-century skills, including critical thinking, creative thinking, problem-solving, communication, and collaboration (Hasanah et al., 2021; Saraswati & Agustika, 2020). Developing the quality of human resources can start with education, as education is the most important catalyst for human resource development (Alifah, 2021; Eni et al., 2020; Safitri et al., 2022). The government has made efforts to improve education by changing the education paradigm and curriculum (Husain & Kaharu, 2020; Wahyuningsih et al., 2023). The current education system has emphasized the importance of developing Higher Order Thinking Skills in learning. Higher Order Thinking Skills are skills that can meet the needs of students in facing the challenges of the times and competing globally where students are required to be able to analyze, evaluate, and create (Anggraeni et al., 2021; Rindiana et al., 2022).

In the current digital and information era, where information is easily accessible, Higher Order Thinking Skills have become increasingly important. Students need to be equipped with high-level thinking skills to tackle complex challenges in their lives, both in school and in everyday contexts. However, in practice, the implementation of Higher Order Thinking Skills in elementary school education is still limited. Teachers often rely on rote memorization and understanding, which represent lower-order thinking skills (Hamdani et al., 2022; Muslim et al., 2022; Rindiana et al., 2022). The learning process is still focused on rote memorization and shallow conceptual understanding. It is important to develop a more holistic and effective approach in teaching elementary school students to enable them to acquire higher-order thinking skills.

The Independent Curriculum is designed to enhance the development of Higher Order Thinking Skills among students in Indonesia. However, developing Higher Order Thinking Skills in students cannot happen instantly and requires continuous time and effort (Kurniasih et al., 2021; Susilowati & Suyatno, 2021). To cultivate strong Higher Order Thinking Skills in students, the most crucial factor is the quality of teachers. Teachers must have a deep understanding of the cognitive processes involved in both lower-order thinking skills and higher-order thinking skills. Teachers play a significant role in optimizing Higher Order Thinking Skills assessments, aiming to train students to tackle Higher Order Thinking Skills questions and understand the categories of their Higher Order Thinking Skills abilities.

Based on previous research, it is known that teachers do not yet understand the concept of Higher Order Thinking Skills and are not prepared to teach or assess questions based on HOTS (Sarudin et al., 2019). Other similar studies also indicate that teachers' knowledge of Higher Order Thinking Skills, their ability to enhance students' Higher Order Thinking Skills, problem-solving-based learning related to HOTS, and activities measuring students' Higher Order Thinking Skills are still weak (Saptono et al., 2020; Satriani et al., 2022). The class teachers involved in the research did not have competence. From this case it can be concluded that there is still a lack of training and assessment activities related to students' higher level thinking abilities (Mariyani, 2019; Suhadi et al., 2021). From these several cases, it can be seen that there is still a lack of training activities and measurement of students' higher level thinking abilities.

The main issue identified during observations was that teachers lack comprehensive understanding of Higher Order Thinking Skills. In interviews conducted at SDN Sumbersari 2 Pasuruan with 4th-grade teachers, it was revealed that Higher Order Thinking Skills are crucial for elementary school students to equip them with good competitiveness. The teachers had attended seminars and training sessions on developing Higher Order Thinking Skills-based questions and assessments, but they had not implemented these strategies optimally. Daily assessments and mid-semester evaluations still predominantly focused on Bloom's Taxonomy levels C1 to C3, with a limited use of C4. Based on these interviews, it was evident that teachers were not aware of the Higher Order Thinking Skills abilities of their students. Overall, this lack of understanding can impact students' abilities to solve more complex problems in the 21st century. The shortage of Higher Order Thinking Skills-based training and assessments affects students' abilities to solve Higher Order Thinking Skills questions and address problems. To foster the development of students' Higher Order Thinking Skills, teachers need to incorporate Higher Order Thinking Skills assessments and utilize teaching methods that encourage Higher Order Thinking Skills in their students.

The learning theories used in education act as a bridge between the information provided and the learning outcomes achieved by students (Kalifah et al., 2022). Learning theories can provide the needs of teachers and learners before learning activities, during learning activities, and after the learning process. Effective learning can be created from various theories needed in learning activities (DeYoung & Krueger, 2018; Hof, 2018; Utomo, 2020). One of the theories that can be applied in learning Higher Order Thinking Skills is cybernetic theory. Cybernetic theory emerges as an interesting potential solution.

Learning according to cybernetic theory is the processing of information (Astawa & Adnyana, 2018; Ertikanto, 2016). This theory considers that learning is a complex system, where inputs, processes, and

outputs are interrelated and influence each other. Cybernetic theory is a learning theory that prioritizes the learning process and uses technology in obtaining fast and appropriate information (DeYoung & Tiberius, 2023; Yunus, 2018). Learning according to cybernetic theory is a teacher's effort to help students achieve learning goals effectively by enabling students' knowledge (DeYoung, 2015; Wahyuna et al., 2023). Applying cybernetic theory in education can offer new experiences and information to students (Telaumbanua et al., 2022; Ziebacz, 2022).

The existence of cybernetic theory is a demand arising from the progress in technology and information, which significantly influences quality education based on information technology (Wahyuna et al., 2023; Yunus, 2018). Cybernetic learning theory also facilitates access to information and eliminates potential obstacles in the learning process when teachers are not physically present in the classroom. Applying cybernetic concepts can create a dynamic and responsive learning environment, aiding students in developing higher-order thinking skills more effectively. Previous research has successfully demonstrated the effectiveness of applying cybernetic theory in learning, enhancing students' understanding and creativity (Azizah et al., 2022; Nur'alimah, 2022). The application of cybernetic theory nurtures students' problem-solving abilities and motivates active participation as students exchange information while collaborating to solve problems. Meanwhile, based on other studies, there is a positive and significant influence observed from the application of cybernetic learning theory on the effectiveness of Islamic Religious Education learning (Arifin et al., 2013; Bakti & Sakdiah, 2021). Based on previous research, cybernetic theory has been effectively applied in teaching and can motivate students. However, studies related to the use of cybernetic theory in enhancing students' Higher Order Thinking Skills have not been conducted before.

The advantages of cybernetic theory include fostering students' critical thinking abilities. Critical thinking skills are essential for the development of students' personalities, enabling them to become individuals who are critical, innovative, and creative, with broad perspectives and knowledge. Cybernetic theory is one of the learning approaches that aligns with the demands and advancements of contemporary times and technology (Donie et al., 2022; Ziebacz, 2022). The presence of cybernetic theory aids teachers in delivering information using available technology media (Arifin et al., 2013; Rogers et al., 2023). Therefore, it is expected that teachers can master cybernetic theory in the components of education. Although the potential of applying cybernetic theory to enhance the Higher Order Thinking Skills of students is intriguing, in-depth empirical research on its influence has not been conducted. This lack of understanding creates a gap in comprehending how cybernetic theory can be concretely applied in primary education. Therefore, this research holds significant relevance and is necessary to fill this knowledge gap, providing a deeper insight into how cybernetic theory can be applied in elementary education.

This research contributes to understanding the application of cybernetic theory in improving the Higher Order Thinking Skills of elementary school students. The study is highly necessary and relevant because it directly relates to the enhancement of the quality of primary education. The results of this research will also inspire educational policymakers to integrate the cybernetic theory approach into the elementary school curriculum, transform the learning paradigm, and enhance the quality of education at the primary level. The novelty of this research lies in the new approach of applying cybernetic theory to enhance the Higher Order Thinking Skills of elementary school students. Therefore, this study aims to analyze the influence of the application of cybernetic theory on the Higher Order Thinking Skills of fourth-grade students in elementary school.

2. METHOD

This study is experimental research. Experimental research aims to determine the influence of a specific treatment on certain conditions or states (Masyhud, 2021). This research used a Quasi-Experimental approach with a Nonequivalent Control Group Design. The population of this study consisted of all fourth-grade students at SDN Sumbersari 2, Pasuruan, totaling 42 students. The sample included all fourth-grade students, divided into Class IV A and IV B. The study employed a simple random sampling technique to determine the experimental and control groups. Class IV A, comprising 20 students, was the experimental group implementing the sibernetik theory-based learning. Class IV B, comprising 22 students, served as the control group undergoing conventional learning.

The experimental group received instruction based on the Cybernetic Theory. The learning process involved the use of Information and Communication Technology (ICT). Students were provided access to smartphones and engaged in learning activities that supported online interactions and real-time feedback. In contrast, the control group participated in conventional learning methods commonly employed by teachers. Learning took place in the classroom using printed textbooks, chalkboards, and workbooks. Interaction between students and teachers was predominantly one-way, with the teacher serving as the

primary source of information. Conventional teaching methods included delivering course content, assigning homework, and conducting written exams.

Data collection was conducted using observation sheets, interview sheets, and multiple-choice tests. Data analysis techniques included quantitative descriptive analysis and independent sample t-test. The interview sheet instrument was utilized to gather teacher responses regarding students' learning experiences. The interview questionnaire used can be found in Table 1.

Table 1. Interview Instrument Grid

No	Aspect	Question
1.	Understanding Higher Order Thinking Skills of Students	1. How do you define high-order thinking skills in students? 2. What indicators do you observe when students have low Higher Order Thinking Skills? 3. How are high-order thinking skills assessed in fourth-grade students?
2.	Challenges in Improving Higher Order Thinking Skills	4. What challenges have you faced when trying to improve the Higher Order Thinking Skills of students with low abilities? 5. What are the obstacles in developing the HIGHER ORDER THINKING SKILLS of students?
3.	Application of Cybernetic Theory to Enhance Higher Order Thinking Skills	6. Do you know cybernetic theory? 7. Have you ever applied cybernetic theory in teaching? 8. What is your opinion on the application of cybernetic theory in enhancing the Higher Order Thinking Skills of low-performing students? 9. How do you perceive the relevance of cybernetic theory in addressing the challenges in developing students' Higher Order Thinking Skills?
4.	Recommendations and Suggestions	10. Do you have any suggestions or recommendations regarding the implementation of cybernetic theory to address the low Higher Order Thinking Skills of students?

Test instruments are used to measure high-order thinking skills. The framework used for collecting data on students' Higher Order Thinking Skills is presented in Table 2.

Table 2. Grid of Test Instruments Based on Higher Order Thinking Skills

No	Achievement Indicators	Question Indicators	Number of Questions
1	Students can mention the kingdoms that have developed in their local area.	Students can identify the kingdom or historical identity that once existed in their local area.	1
		Students can explain the main factors that influenced the development of that kingdom.	1
2	Students can narrate the origins of their region and the local figures who played significant roles in its development.	Students are able to introduce local figures who played important roles in the history of their region.	1
		Students are able to provide relevant information about the roles of these figures in the development of the region.	1
3	Students can mention positive qualities that can be emulated from local figures in their region.	Students can mention positive qualities that can be emulated from local figures in their area.	1
		Students can provide reasons why these qualities are important and can be used as examples.	1
4	Students compare the conditions of their local area in the past and present.	Students are able to compare the conditions of their local area in the past and the present.	1
		Students can identify significant changes and explain the factors that might have caused these changes.	1
5	Students explain the importance of preserving	Students can explain with strong arguments why it is important to preserve historical heritage in their local area.	1

No	Achievement Indicators	Question Indicators	Number of Questions
	the historical heritage of their local area.	Students can provide convincing reasons about the importance of preserving cultural and historical heritage.	1

3. RESULT AND DISCUSSION

Result

The data processing and analysis involved conducting pretests and posttests in both Class IV A (experimental group) and Class IV B (control group) at SDN Sumbersari 2 Pasuruan. Based on this data, conclusions can be drawn regarding the impact of the application of cybernetic theory on students' Higher Order Thinking Skills. The posttest results from the application of cybernetic theory in Class IV A (experimental group) were higher than those in the control group (Class IV B). To measure the extent of the impact of cybernetic theory on Higher Order Thinking Skills, an independent sample t-test was conducted. Before comparing the pretest and posttest results, homogeneity and normality tests were performed. Once both classes were determined to be homogeneous and the pretest and posttest scores were normally distributed, an independent sample t-test was conducted to test the mean differences.

The homogeneity test was conducted to determine whether the two classes used as research samples originated from the same variance. The results of the homogeneity test can be observed in Table 3.

Table 3. Homogeneity Test

Levene Statistic	df1	df2	Sig.
0.000	1	40	0.993

Based on the homogeneity test results in Table 3, with a homogeneity test value of 0.993 (0.993 > 0.05), it can be concluded that the two classes used as research subjects are homogeneous or have the same variance. After confirming the homogeneity of the classes, the learning process will proceed.

Both classes were tested using the same test instruments, namely pretest and posttest. After obtaining the pretest and posttest results, these results were subjected to the Shapiro-Wilk normality test. The normality test was used to determine whether the data followed a normal distribution or not. The results of the normality test can be observed in Table 4.

Table 4. The results of the Shapiro-Wilk Normality Test

No	Variable	Statistic	df	Sig.	Description
1	Class IV A Learning Outcomes	0.910	20	0.64	Normal distribution
2	Class IV B Learning Outcomes	0.961	20	0.98	Normal distribution

Based on Table 4 of Shapiro-Wilk normality test results presented earlier, the following is a description of the normality test results for each variable.

Based on the normality test results, it can be concluded that the data is normally distributed. Therefore, further statistical analysis was conducted using an independent samples t-test to determine the mean differences between the two classes (Sugiyono., 2019) utilizing SPSS Statistics 24. The results of the independent samples t-test analysis can be observed in Table 5.

Table 5. Results of Statistical Analysis of Independent Sampling t-test

	Class	Mean	Std. Deviation	t	df	Sig. (2-tailed)
Student's HOTS	IV A	86.40	4.260	9.645	40	0.000
	IV B	68.86	7.039			

Based on Table 5 show the results of the independent samples t-test, it can be analyzed that the calculated t-value is larger than the critical t-value (9.645 > 1.684), indicating a significant difference between the experimental group applying cybernetic theory-based learning and the control group implementing conventional learning. The low significance value (Sig. 2-tailed = 0.000 < 0.05) suggests a significant difference between the two compared groups in the tested variable. A Sig. 2-tailed value less than 0.05 allows rejecting the null hypothesis (H0) which states no difference between the two groups. This

means there is enough evidence to support a significant difference between the control and experimental groups in the tested variable.

Discussion

The study employed an independent sampling t-test to compare the effects of Cybernetic Theory-based learning applied by the experimental group (class IV A) to the conventional learning followed by the control group (class IV B). The t-test revealed a significant difference between the two groups in their Higher Order Thinking Skills abilities, as the t count of 9.645 exceeded the t table of 1.684. Furthermore, the p-value (2-tailed) is extremely low (0.000), indicating a significant difference. The large t-value coupled with the very low p-value (2-tailed) demonstrates a significant difference between the two groups concerning fourth-grade students' higher-order thinking abilities. This noteworthy difference suggests that utilizing cybernetic theory in learning has a constructive impact on students' higher-order thinking skills. The group that was subjected to the application of cybernetic theory in their learning showed significantly higher average learning outcomes than the control group that did not receive the application.

The results of this study are consistent with previous research findings, supporting the effectiveness of cybernetic theory in learning. Previous studies have shown that cybernetic theory can enhance learning outcomes and develop problem-solving abilities. However, the recent discovery from this study is that cybernetic theory can enhance students' higher-order thinking skills or Higher Order Thinking Skills. Cybernetic theory can elevate students' Higher Order Thinking Skills by directly involving them in the learning process. Students engaged in learning through the application of cybernetic theory demonstrated significant improvement in their higher-order thinking abilities compared to those who did not experience this application. They were capable of applying systemic and holistic thinking to problem-solving, evaluating existing solutions, and generating new ideas. This provides strong empirical support for the effectiveness of cybernetic theory as a learning approach in enhancing students' Higher Order Thinking Skills. Cybernetic theory, emphasizing system modeling, feedback, and interactions between components, can facilitate critical thinking, complex problem-solving, and creativity among students (Bakti & Sakdiah, 2021; Nur'alimah, 2022).

There are three indicators of higher-order thinking skills: analysis, evaluation, and creation (Basri et al., 2022; Rohman et al., 2020; Sarudin et al., 2019). Analytical ability is possessed when students are faced with problems that they need to solve, inspiring them to find solutions. Evaluation skills are acquired when students reach conclusions by evaluating and assessing solutions to given problems. Additionally, assessment is carried out by students when they analyze the issues they face. By generalizing ideas into problem-solving as a result of cybernetic theory activities, students develop analytical skills. Higher Order Thinking Skills activities require students to engage in critical and creative thinking guided by meaningful and accurate thoughts (Kurniasih et al., 2021; Shanti et al., 2022). These critical thinking activities are interrelated, such as standards and values.

The application of cybernetic theory becomes a crucial key in education to embrace the era of 5.0 (Geoghegan, 2020; Ziebacz, 2022). Cybernetic theory can assist students in higher-order thinking, especially in critical thinking (Bakri et al., 2020; Suminar, 2019). The application of cybernetic theory has been proven to significantly impact the improvement of students' higher-order thinking skills. This is because the steps or procedures in cybernetic theory can direct students to actively engage in learning. Teachers encourage their participation in activities such as discussions, Q&A sessions, and group work. Students are also encouraged to exchange ideas, share knowledge, and learn from each other. The use of technology or interactive learning can enrich students' learning experiences and help them better understand concepts. Continuous evaluation is conducted to monitor students' progress and identify areas that need improvement. Students reflect on their learning and provide feedback about their learning experiences. In this application of cybernetic theory, students are encouraged to optimize their higher-order thinking skills. The application of cybernetic theory can be an effective approach to enhance students' Higher Order Thinking Skills. By focusing on problem-solving, evaluation, and creativity, students can develop the high-level thinking skills necessary to tackle complex learning challenges in the future and prepare them to be proficient and adaptable thinkers in our ever-evolving society.

Therefore, this research makes a significant contribution in the context of learning in fourth-grade elementary classrooms, demonstrating that the application of cybernetic theory can positively influence students' Higher Order Thinking Skills. The findings of this research have important practical implications. Firstly, the cybernetic theory-based learning approach can be implemented in fourth-grade classrooms to enhance students' Higher Order Thinking Skills. Teachers can utilize the principles of cybernetic theory to design more interactive learning experiences, involve students in system modeling, and encourage reflective thinking. Moreover, this research also holds important theoretical implications. These findings can enrich our understanding of effective learning approaches in advancing students' cognitive abilities.

Cybernetic theory, as a relatively new approach in the educational context, can be integrated with existing learning theories to develop a stronger foundation in teaching and learning methodologies.

Although this research provides valuable insights into enhancing understanding of learning approaches that can improve Higher Order Thinking Skills at the elementary school level, it also has limitations that need to be acknowledged. First, limitations in sample size and the diversity of students' geographic locations can affect the generalizability of the research findings. To address this, future research could consider involving more schools and classrooms to obtain a more representative sample. Additionally, this research did not account for factors that could influence Higher Order Thinking Skills. Possible internal factors such as low interest and motivation in learning, as well as external factors like the learning environment or parental support were not considered. To address this, future research could analyze the factors influencing the development of Higher Order Thinking Skills in its discussions. By overcoming these limitations, future research can provide more comprehensive results in efforts to enhance the quality of elementary education.

4. CONCLUSIONS

This research was conducted to evaluate the impact of implementing cybernetic theory on the Higher Order Thinking Skills of fourth-grade elementary school students. Through an independent sample t-test, the results of this study showed a significant difference between the experimental group, which received the application of cybernetic theory in learning, and the control group, which did not receive this application. Based on these results, it can be concluded that the implementation of cybernetic theory has a positive and significant effect on the Higher Order Thinking Skills of fourth-grade elementary school students. The experimental group that received the application of cybernetic theory in learning demonstrated significantly higher average learning outcomes compared to the control group that did not receive this application.

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