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The Impact of Self-Organized Learning Environment Model and STAD Cooperative Model on Knowledge Competency in Terms of Learning Independence in Dynamic Fluids Material

Adi Setiawan[1], Pujayanto[2*], Ahmad Fauzi[2]

[1] Physics Education, Faculty of Teacher Training and Education, Sebelas Maret University, Surakarta, Indonesia.
[2] Master of Science Education Program, Sebelas Maret University, Surakarta, Indonesia.

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Corresponding Author:
Pujayanto
pujayanto@staff.uns.ac.id

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Abstract: This study aims to investigate the differences in the effect of using Self-Organized Learning Environment and STAD cooperative learning models supported by the Sigil module on knowledge competency in terms of learning independence, and to investigate the differences in the effect of different categories of student learning independence on student knowledge competency. This study aim also to investigate interaction between learning independence with Self-Organized Learning Environment model and STAD cooperative learning model on student knowledge competency. The type of this research is a quasi-experiment. Using the cluster random sampling technique, class XI MIPA 1 was chosen as the experimental class, and class XI MIPA 3 as the control class. Data were collected using documentation, test, and questionnaire distribution methods. Data were analyzed using a two-way ANOVA technique followed by multiple comparison tests using Scheffe's method. The results of the study indicate that there is no difference in the effect of Self-Organized Learning Environment and STAD cooperative learning models supported by the Sigil module on students' knowledge competency, and there is a difference in the effect between categories of student learning independence on knowledge competence. This study also proves that there is no interaction effect of the use of learning models and learning independence on knowledge competency.

Keywords: Learning independence; Learning models; Knowledge competency

Introduction

Physics is a combination of products, processes, attitudes, and technology (Astalini et al., 2019). The 2019 Trends in International Mathematics and Science Study (TIMSS) report revealed that Indonesian students' average physics achievement is still below the global average, coming in at only 383 points whereas the global average is 475 points (IEA, 2020). Guido (2018) stated that the factor causing students' lack of interest in physics is the perception that physics is a difficult subject. The physics materials, such as dynamic fluids, can be challenging for students to comprehend (Sari & Rustana, 2018). Internal and external factors such as students' interest, motivation, learning independence, cognitive ability, teaching quality, learning resources, and learning environment all influence students' ability to absorb the subject (Arista et al., 2013).

According to Fadhillah et al. (2016), learning independence includes students' ability to plan goals, choose effective strategies, manage time, and evaluate learning outcomes. In terms of external factors, the utilization of teaching materials plays a pivotal role in supporting successful learning. Many teaching materials can be used, one of which is the Sigil e-module. Sigil, which stands for "Simple Interface for Growing Independent Learners", is user-friendly open-source

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software for creating and editing interactive e-books (Malik, 2021).

As stated by Festiyed et al. (2023), the choice of learning models can have an impact on students' learning outcomes in physics. However, in practice, many teachers still rely on conventional methods, such as the lecture method, which is predominantly teacher-centered (Rivalina & Siahaan, 2020). To effectively facilitate students' learning, teachers need to possess various competencies, including personality, professional, social, and pedagogical competencies. These competencies can be linked to the Technological Pedagogical Content Knowledge (TPACK) framework. Integrating TPACK with different learning models, such as the Self-Organized Learning Environment (SOLE) model and the Student Teams Achievement Division (STAD) cooperative model, can be highly beneficial (Nasution et al., 2018; Kusasi, 2021; Marlina, 2021; Abyan et al., 2022; Satriani et al., 2022). The STAD cooperative learning model has been shown to have a positive impact on improving students' physics learning outcomes (Lovisia, 2019). A study by Satriani et al. (2022), investigating the effects of the SOLE learning model on student achievement in physics, has revealed that the implementation of this model had a positive influence on learning outcomes. This is because SOLE promotes students' learning independence, aligning with the indicators of independent learning (Firdaus et al., 2021).

Based on the given description, the chosen title for the study is "The Impact of the Self-Organized Learning Environment Model and the STAD Cooperative Model on Knowledge Competency in Terms of Learning Independence in Dynamic Fluid Material". The objectives of this study include: to determine the differences in influence between the utilization of the Self-Organized Learning Environment model and the TPACK-based STAD cooperative model, both supported by the Sigil module, on knowledge competency; to investigate the disparities in the influence of different categories of learning independence on student knowledge competency; to analyze the interaction effect between student learning independence and the use of TPACK-based learning models supported by the Sigil module on student knowledge competency.

This study postulates the following hypotheses: there is a difference in the effect of the Self-Organized Learning Environment model and the TPACK-based STAD cooperative model supported by the Sigil module on student knowledge competency; there is a difference in the effect of student learning independence and student knowledge competency; and there is an interaction effect between student learning independence and the adoption of TPACK-based learning model supported by the Sigil module on student knowledge competency.

Method

The research was conducted at SMA 5 Surakarta from September 2022 to April 2023, employing a quasi-experimental method and a 2x3 factorial design. The experimental class XI MIPA 1 and the control class XI MIPA 3 were selected as samples using the cluster random sampling technique. The experimental group received instruction using the TPACK-based Self-Organized Learning Environment (SOLE) model supported by the Sigil module, while the control group was taught using the TPACK-based Student Teams Achievement Division (STAD) cooperative model supported by the Sigil module. Data were collected using various methods, including tests, documentation, and questionnaire distribution. The data analysis process involved conducting prerequisite tests to assess normality and homogeneity, testing hypotheses using the ANOVA test, and performing post hoc tests.

Results and Discussion

Student Learning Independence Data

Table 1 summarizes data related to student learning independence for the experimental class.

Table 1. Learning Independence of Experimental Class Students

Learning Independence	Number of Students	Percentage (%)
High	10	28
Medium	19	53
Low	7	19
Total	36	100

Table 1 presents the distribution of students based on their levels of learning independence. Among the total number of students, 10 students (28%) demonstrated a high level of learning independence. The majority of students, comprising 19 students (53%), exhibited a medium level of learning independence, while 7 students (28%) displayed a low level of learning independence.

Table 2 displays the frequency distribution of student learning independence within the control class. Among the total number of students, 8 (22%) demonstrated high levels of learning independence. The majority of students, accounting for 16 (44%), exhibited medium levels of learning independence. Additionally, 12 students (33%) displayed low levels of learning independence. For a comprehensive overview of the experimental and control classes' respective learning independence distributions, please refer to Figure 1.

Table 2. Learning Independence of Control Class Students

Learning Independence	Number of Students	Percentage (%)
High	8	22
Medium	16	44
Low	12	33
Total	36	100

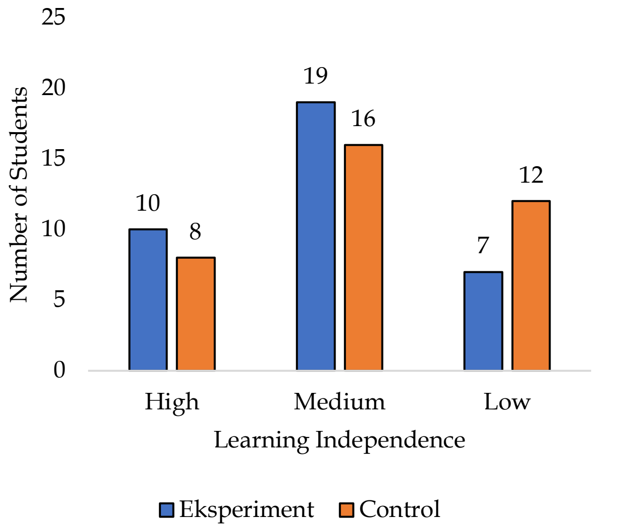

Figure 1. Distribution of students' learning independence in experimental and control classes

Figure 1 illustrates the distribution of learning independence across various categories, highlighting a higher representation in the medium category. Specifically, within the experimental class, the number of students exhibiting high and moderate levels of learning independence surpasses that of the control class. Conversely, in the low category, the experimental class has fewer students compared to the control class.

Student Knowledge Competency Data

Knowledge Competency data were obtained through a knowledge competency test containing 25 multiple-choice questions given after the experimental and control classes were given the treatment. A summary of student ability data in the experimental and control classes is presented in Table 3.

Table 3. Summary of Students' Knowledge Competency

Class	Total data	Learning outcomes	
		Mean	Standard deviation
Experiment	36	66.94	11.99
Control	36	66.88	10.50

Table 3 explains that the experimental class has an average of 66.94 with the lowest score of 40 and the highest score of 88, while the control class has an average of 66.83 with the lowest score of 40 and the highest score of 92. The diagram of the distribution of knowledge competency scores in the experimental class is presented in Figure 2, while the control class is presented in Figure 3.

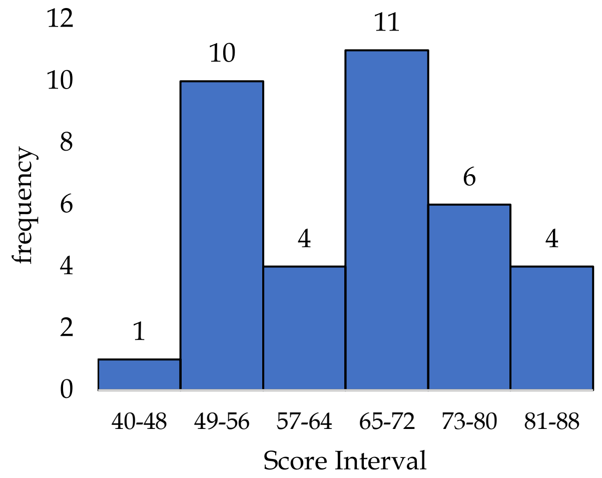

Figure 2. Histogram of knowledge competency score of experimental class students

Based on the data presented in Figure 2, it is evident that the experimental class exhibits the highest frequency of knowledge scores within the range of 65–72, encompassing a total of 11 students. Following this, the range of 49–56 comprises 10 students, while the range of 73–80 encompasses 6 students. Subsequently, the ranges of 57–64 and 81–88 each consist of 4 students, and the final range of 40–48 includes a single student, resulting in a total of 36 students.

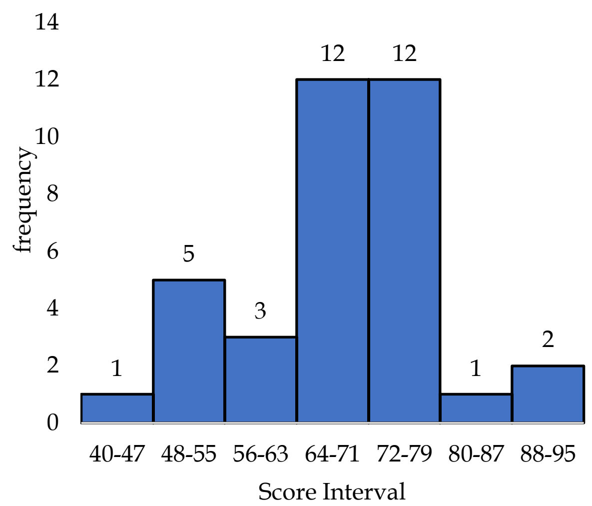

Figure 3. Histogram of knowledge competency score of control class students

Based on the data depicted in Figure 3, it is evident that the control class demonstrates the highest frequency of knowledge scores within the ranges of 64–71 and 72–79, each comprising 12 students. Subsequently, the range of 48–55 encompasses 5 students, while the range of 56–63 involves 3 students. Moreover, the range of 88–85 consists of 2 students, and both the ranges of 40–47 and 80–87 encompass 1 student each. Consequently, the total number of students amounts to 36.

Prerequisite Test Analysis

The results of the normality test are presented in Table 4 below.

Table 4. Normality Test Results

Class	Sig. (0.05)	Conclusion
Experiment	0.200	Normally Distributed
Control	0.053	

Furthermore, the results of the homogeneity test are displayed in the following Table 5.

Table 5. Homogeneity Test Results

Homogeneity Test	Sig. (0.05)	Conclusion
Experiment-Control	0.272	Homogenous

Hypothesis Test

Table 6 shows the results of the two-way ANOVA test.

Table 6. Results of the Two-Way ANOVA Test

Variation	F_{count}	F_{table}	Decision
Learning Model (A)	1.106	3.98	H_{0A} Accepted
Learning Independence (B)	24.205	3.13	H_{0B} Rejected
Interaction (AB)	0.958	3.13	H_{0AB} Accepted

After conducting a two-way ANOVA test, the second hypothesis shows that H_{0B} is rejected. Therefore, a post hoc test was conducted. Table 7 presents the results of the data obtained.

Table 7. Results of Multiple Comparison Test of Means Between Columns

Comparison	Mean X.i	Mean X.j	F_{count}	F_{table}	Conclusion
X1 vs X2	78.44	66.04	23.84	6.26	X1 > X2
X1 vs X3	78.44	57.68	51.97	6.26	X1 > X3
X2 vs X3	66.04	57.68	17.33	6.26	X2 > X3

The mean scores of students are represented by X_1 for those who exhibit high levels of learning independence, X_2 for those who demonstrate medium levels of learning independence, and X_3 for those who display low levels of learning independence.

Hypothesis I

Based on the ANOVA results with a significance level is 0.05, it was discovered that $F_{count} = 1.106 < F_{table} = 3.98$, indicating that hypothesis H_{0A} is accepted. Therefore, it can be concluded that there is no difference in the effect of the application of the Self-Organized Learning Environment learning model and the TPACK-based STAD cooperative model supported by the Sigil module on knowledge competence.

The mean value of knowledge competence in the experimental class is 66.94 and the control class is 66.88 (Table 3). Since the average values show an insignificant difference, it can be inferred that the treatment given to students in the experimental class does not result in significantly different knowledge competency outcomes compared to the control class. Despite having different learning frameworks, SOLE and STAD cooperative TPACK-based learning models encourage students' participation in learning, putting them at the center of the learning process.

The SOLE and the STAD cooperative models have some similarities in terms of collecting data, discussing in groups, and presenting the results of discussions. However, there is a certain aspect that does not significantly impact students' knowledge competencies, such as giving rewards. Research suggests that giving rewards does not have a significant influence on students' academic achievement. Although it may provide short-term motivation, its impact on students' learning outcomes in the long term tends to be minimal (Deci et al., 1999).

The SOLE learning model is based on constructivist principles, emphasizing that students learn through experiences and problem-solving cases, leading to the meaningful construction of knowledge (Mitra & Crawley, 2015). Students are encouraged to explore, collaborate, and exchange information with their peers. Thus, the SOLE learning model treats students as active learners who are responsible for their own education.

Several studies have been conducted to test the effectiveness of the SOLE learning model. This learning model has been proven to have a positive effect on learning outcomes, with the learning process using the SOLE model being rated as highly effective (Novianti et al., 2022). Furthermore, research conducted by Setyorini et al. (2022) found that the SOLE learning model can foster students' critical thinking and learning independence, which in turn positively impacts their academic achievement. The research findings consistently demonstrate that the implementation of the SOLE learning model has a positive impact on students' academic achievement.

Nonetheless, the application of the TPACK-based Self-Organized Learning Environment model also poses challenges for educators. This model requires students to organize themselves and learn in groups with the assistance of internet resources (Dolan et al., 2019). It means that students who do not have adequate access to technology and the internet may face difficulties (Weisblat et al., 2019). The SOLE model requires a high degree of self-learning ability, which can be challenging for students who encounter problems in terms of motivation, cognition, metacognition, self-efficacy, and metacognitive components (Gambo & Shakir, 2021). Another challenge is that teachers must assist and guide students while also allowing them to take responsibility for their own learning. Having a flexible teaching approach and being adaptable to students' needs are key requirements for educators (Pratama & Risdianto, 2021). With careful planning and adequate support, educators can successfully implement the SOLE model and create an engaging learning experience for their students.

The STAD cooperative learning model aims to improve students' ability to work together and their cooperative abilities and social skills. This model also encourages students to help each other in achieving goals. Research by Isnaniah et al. (2022) showed that implementing the STAD cooperative learning model has a positive impact on cognitive learning outcomes. However, the implementation of this model may encounter a challenge in terms of effectively managing time to ensure the completion of the learning process within the allocated timeframe and the achievement of learning objectives. Through careful consideration of student preparation and the availability of resources and infrastructure to ensure the smoothness of the learning process, the Self-Organized Learning Environment and the STAD cooperative learning models can be applied in physics learning.

Hypothesis II

Based on the ANOVA test results with a significance level of 0.05, the result obtained is F_{count} = 24.205 > F_{table} = 3.13, indicating that the H_{0B} hypothesis is rejected and there are differences in the influence of high, medium, and low learning independence on student knowledge competence. The research findings reveal that the average knowledge competency scores are 78.44 for students with high learning independence, 66.04 for those with medium learning independence and 57.68 for those with low learning independence.

The findings of this study align with the research conducted by Sanita et al. (2021), which suggests that improving student learning outcomes can be achieved through the cultivation of students' learning independence. According to Nasution et al. (2018), students with a high level of learning independence have better results than students with a moderate or a low level of learning independence. The cultivation of student learning independence is intended to enable mastery of desired competencies, thereby enabling the accomplishment of learning objectives in terms of knowledge and skills. This is also in line with the research of Hidayat et al. (2019) and Eduard et al. (2022), which explains that student learning independence has a significant correlation with learning outcomes. In conclusion, the outcomes of students' knowledge competencies are influenced by their level of learning independence.

Hypothesis III

Based on the results of the ANOVA test with a significance level of 0.05, wherein F_{count} = 0.958 < F_{table} = 3.13, the null hypothesis (H_{0AB}) is accepted, indicating no significant interaction between the learning models and learning independence in relation to students' knowledge competency. Although the learning models employed in this study have distinct focuses, they exhibit a similar impact on students' knowledge competency. The SOLE learning model emphasizes student independence in knowledge construction through effective planning, whereas the STAD cooperative learning model centers around interaction and collaboration within groups. Furthermore, students with higher levels of learning independence demonstrate better adaptability to a learning style that does not rely heavily on teacher guidance.

It is important to note that various internal and external factors, beyond the control of researchers, can influence students' outcomes. Research conducted by Jufrida et al. (2019) highlights internal factors such as interest, learning style, motivation, and intelligence level can affect learning outcomes. External factors, including family environment, school environment, and socioeconomic conditions, also play a significant role. Similar findings have been presented by Alza et al. (2021), indicating no significant interaction between learning models and learning independence on students' cognitive learning outcomes. The data suggests that there are no discernible differences in the cognitive skills of students with different levels of independence between the experimental and control classrooms.

Conclusion

This study concludes that: there is no significant difference in the effect of using the Self-Organized Learning Environment model and the STAD cooperative model, both based on TPACK and supported by the Sigil module, on student knowledge competency; there is a notable difference in the effect of student learning independence on knowledge competency; and there is no interaction effect between the use of learning models and student learning independence on knowledge competence. Teachers are advised to optimize the learning process design, starting from the structure of instructional methods, the availability of facilities and infrastructure to support the continuity of learning to achieve learning goals, and to take into account students' autonomy in making decisions regarding their learning activities.

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Conceptualization, Adi Setiawan, Pujayanto, and Ahmad Fauzi; formal analysis, Adi Setiawan, Pujayanto, and Ahmad Fauzi; investigation, Adi Setiawan; data curation, Adi Setiawan; writing—original draft preparation, Adi Setiawan; writing—review and editing, Adi Setiawan, Pujayanto, and Ahmad Fauzi; supervision, Pujayanto, and Ahmad Fauzi.

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Conflicts of Interest
The authors declare no conflicts of interest.

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