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Implementation of Flipped Learning Approach with A Guided Inquiry Model to Science Process Skills & Chemical Literacy on Reaction Rate Material

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Abstract: This study investigates the impact of a flipped learning approach combined with a guided inquiry model on students' science process skills and chemical literacy in reaction rate material. The quasi-experimental research employed a non-equivalent pretest-posttest control group design with 71 eleventh-grade high school students as participants. Instruments included a chemical literacy test and a science process skills observation sheet. Data analysis using MANOVA revealed significant differences and effects between the guided inquiry-flipped learning and discovery learning models, with an effective contribution of 29.70%. These findings highlight the positive influence of the guided inquiry and flipped learning approach on enhancing science process skills and chemical literacy.

Keywords: Chemical literacy; Flipped learning; Guided inquiry; Science process skills

Introduction

Education is an important sector in measuring a country's progress. Educational progress is determined by Human Resources (HR). Efforts to develop the education system can be carried out through increasing competency in science process skills and scientific literacy (Mardianti et al, 2020). Based on 2018 PISA data, Indonesia's scientific literacy score is at level 1 (low) with a score of 396 (Schleicher, 2019). One of the scientific literacy includes chemical literacy. The low chemical literacy abilities of students in Indonesia are influenced by several factors, namely the applicable education system and curriculum, learning methods and models, learning tools and facilities, teaching materials, and learning resources (Viendrieana et al., 2021).

Learning chemistry requires science process skills which are closely related to laboratory skills. In school learning, students are passive in receiving material, tend to memorize rather than understand the material, and relate chemical material to real life (Seprianto & Hasby, 2023). Teachers' activeness in teaching is not balanced with students' activeness in learning. This causes students to only know the concepts without understanding more deeply how to find chemical concepts (Firmansyah & Khumaidah, 2017). The lack of student involvement in learning causes a lack of training in science process skills.

Learning cannot be separated from choosing a learning model. The learning model is a guideline for designing teaching and learning activities (Wulandari & Totalia, 2016). The guided inquiry learning model allows students to learn from experience and improve their abilities. Students experience a dynamic and active learning process in learning. Learning with guided inquiry can also improve students' cognitive abilities. Apart from cognitive aspects, affective, and psychomotor aspects also increase in learning with this model (Öztürk et al., 2022)

Technology and education cannot be separated from human life today. Learning to use technology in the pandemic era not only has positive impacts but also

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negative impacts (Al Aslamiyah et al., 2019). Some students cannot understand the material well through distance learning because the students' ability to grasp the material is different from other students. One solution is to implement flipped learning-based learning. Learning with flipped learning provides an interaction environment between students and teachers and involves application and practice (Awidi & Paynter, 2019). The flipped classroom uses a learner-centered approach because it focuses on the learner's learning and places more responsibility for learning on the learner as opposed to the teacher. Teachers play a role in encouraging to experiment (Danker, 2015). Students can understand material at their own pace and ability so that learning can be achieved.

Chemistry lessons have a wide range of materials. One of the materials studied in chemistry subjects in the high school curriculum is reaction rates. Reaction rate material requires mastery of concepts through scientific literacy and process skills with experiments, so that in learning it is not enough for students to memorize the material (Marthafera et al., 2018). Based on research by Fitriana et al. (2019), learning activities in the classroom should be connected to experiments that can enable chemistry to be conveyed to students in a real way and students experience learning directly, thereby creating meaningful learning.

This study has a fundamental difference compared to previous studies because it integrates the flipped learning and guided inquiry approaches, which specifically focus on improving science process skills and chemical literacy, not just on learning outcomes. Research conducted by Kim & Ahn (2018), shows that flipped learning and guided inquiry-based learning can significantly improve student learning outcomes. This approach is effective in extending learning time, allowing students to gain more knowledge, and encouraging individual responsibility for learning, so that students can engage more deeply (Hwang et al., 2015). In addition, discussion activities in guided inquiry are facilitated by providing opportunities for students to take responsibility for their learning. Students are also given many opportunities to communicate and discuss with classmates, which can ultimately improve their collaboration skills and understanding of the material being studied.

The combination of guided inquiry and flipped learning has been proven to provide better results in improving learning outcomes. The flipped learning approach allows students to learn independently before the learning process in class, while guided inquiry provides a systematic framework to support students in understanding concepts in depth (Putra et al., 2023). This combination is also able to increase students' activeness and motivation to learn.

Previous research on guided inquiry and flipped learning has been widely conducted, but the combination of these two approaches is still rarely applied, especially in efforts to improve scientific literacy and science process skills simultaneously on the material of reaction rates. The material of reaction rates has unique characteristics that require understanding through experiments to explain abstract concepts, so this approach is relevant to apply. Focused more on the development of learning media without exploring the effect of this combination of models on chemical literacy and science process skills.

Based on the results of observations, the low scientific literacy ability of students is caused by the lack of evaluation questions that contain indicators of scientific literacy. Teachers often give simple descriptive rather than scientific literacy-based questions, so students are not trained to analyze, evaluate, and apply scientific concepts in real contexts. In addition, students' science process skills are not optimal due to the lack of experimental activities. Student activity in learning is also still low, which indicates the need for learning models and approaches that can increase student participation and create meaningful learning experiences.

Based on this description, this study was conducted to apply a combination of guided inquiry learning models with a flipped learning approach to improve high school students' science process skills and science literacy in the reaction rate material. This study is expected to provide new contributions to innovative chemistry learning strategies, especially in Indonesia, and become a reference for learning that is relevant to the needs of students in the 21st century.

Method

This study used quasi-experiment research with a non-equivalent pretest-posttest control group design (Creswell, 2009). One group was used as the experimental group, and the other as the control class. The experimental group was taught using the flipped learning with guided inquiry model, while the control group was taught using discovery learning model. Science process skills and chemistry literacy were measured before and after implementation flipped learning with guided inquiry. The research design is shown in Table 1.

Table 1. Research Design

Group	Pretest	Treatment	Posttest
Experiment	0_1	$X_1, 0_2$	0_1
Control	0_1	$X_2, 0_2$	0_1

Information:

0_1 = Chemical literacy test

0_2 = Science process skills observation sheet
X_1 = Guided inquiry model with a flipped learning
X_2 = Discovery learning model

Students in 11th grade from senior high school were taken as research samples. The selection of the research sample using a cluster random sampling technique. The first stage aims to randomly select senior high school in the district and select one senior high school. Thus, the second stage of random cluster sampling determines the classes used as the experimental and control classes.

The instruments in this study consisted of tests (pretest-postest) and observation sheet. The test instrument contains 5 rate reaction essay questions. The results of the students written test can be seen through the score obtained by the student, which is a maximum score of 100. The observation instrument contains an six aspects of observation, namely the skills of observing, classifying, communicating, measuring, predicting and concluding. The scale used in assessing students' science process skills is the Likert scale which consists of 4 scales (Harpe, 2015). The data collection techniques used is test and observation. The test aims to measure chemical literacy. Observations are determined through assessment of observations made by observers while students are carrying out experiments.

Multivariate Analysis of Variance (MANOVA) was used to determine the significant effect of implementation and influence flipped learning with discovery learning model on science process skills and chemistry literacy (Huang, 2020). After the MANOVA prerequisite tests are met, proceed with the MANOVA test. In MANOVA results, the Partial Era Squared test is used to determine the percentage influence of the independent variable on the dependent variable.

Result and Discussion

The validation of the test instrument consists of theoretical and empirical validation, while the instrument is a theoretical observation of scientific process skills. Empirical validity was tested in class 12 who had studied reaction rate material as many as 53 students. The results of the chemistry literacy test showed that there were 2 invalid questions out of the 12 essay questions. These two items have a calculated r that is smaller than the r table so these items are eliminated. Meanwhile, the Cronbach's α value is 0.466 in the sufficient category (Duli, 2019). Valid and reliable questions are used for field tests in control and experimental classes.

Before carrying out the MANOVA test, MANOVA prerequisite tests are carried out, including univariate and multivariate outlier tests, normality tests, linearity tests, homogeneity tests, and multicollinearity. Based on the linearity test analysis data, a significance value of 0.256 was obtained, which means there is a linear relationship between the chemical literacy variables and scientific process skills in each dependent variable as shown in Table 2.

Table 2. Linearity Test

			Sig.
Science process skills * n_gain	Beetween groups	Combined	0.23
		Linearity	0.03
		Deviation from linearity	0.26

Based on SPSS calculations, it can be concluded that the MANOVA prerequisite tests have been fulfilled in their entirety so that the research data can be analyzed in a multivariate manner. The first hypothesis was carried out to determine the differences in science process skills and chemical literacy between students who followed the guided inquiry and flipped learning models compared to students who were taught using the discovery learning model. The MANOVA test results obtained a significance value of 0.000 (smaller than 0.05) for Pillai's trace, Wilks's lambda, Hotelling's trace, and Roy's largest root (Sutrisno & Wulandari, 2018). This means that H_0 is rejected, indicating that the guided inquiry and flipped learning models provide a significant difference in students' chemical literacy and science process skills compared to students using the discovery learning model on reaction rate.

The second hypothesis testing was carried out to determine the effect of science process skills and chemical literacy on students who followed the guided inquiry and flipped learning models compared to students who were taught using the discovery learning model. The test was carried out using the partial eta squared test, then converted into a percentage. The practical eta squared value for experimental class data is 0.297 which is equal to 29.70%. This means that the percentage of influence from applying the guided inquiry model with the flipped learning approach compared to students using the discovery learning model on the variables of science process skills and chemical literacy is 29.70%. The significance value in this section shows 0.000 < 0.05, which shows that there is an influence of science process skills and chemical literacy between students who follow the guided inquiry model and flipped learning with discovery learning on reaction rate material (Purba et al., 2021).

Application of Guided Inquiry Learning with a Flipped Learning Approach in Improving Science Process Skills and Chemical Literacy

The results of the first hypothesis test showed differences between treatments in the experimental class and the control class. Learning with a flipped learning approach provides students with the opportunity to study learning material before class starts through teaching modules or learning videos. Students answer questions on the form provided regarding the material to find out whether or not they have finished reading the material in the teaching module and the extent of their understanding of the material. Providing reaction rate material before teaching aims to ensure active discussion between teachers and students when learning takes place in class (Zainuddin & Halili, 2016). Students can ask questions about parts of the material that they do not understand.

Learning in the next class uses guided inquiry syntax which encourages students to be active in learning, especially when included in discussion groups (Rands et al., 2021). Students find solutions to problems by identifying problems, formulating hypotheses, designing and conducting experiments, collecting and analyzing data, and making conclusions (Mahdian et al., 2019). Overall, the learning steps of students in the experimental and control classes are quite similar, except that in the experimental class, the material is given before class learning takes place.

Students' psychomotor skills are not well trained because not all chemistry material is equipped with practical work and students only carry out steps as directed by the teacher (Wardani & Firdaus, 2019). Practical activities are a means for students who play a role in increasing the success of the learning process, especially in science process skills. Learning that connects material with everyday life can foster students' attitudes of concern for the environment and attitudes that support chemical literacy skills (Anggraeni et al., 2020).

Learning using technology assistance can combine the roles of teachers and technology with a flipped learning approach (Maullidyawati et al., 2022). Learning materials are provided before class starts using videos and teaching modules (Mukhlisa et al., 2021). Improving science process skills and chemical literacy is supported by a learning model that is able to make students active in discovering concepts in the material using a guided inquiry learning model with a flipped learning approach.

In fact, the research carried out produced MANOVA test results with a significance of 0.000 (less than 0.05). This is in accordance with the theory and research that has been presented. The students' posttest results on the application of guided inquiry using the flipped learning approach were better than those with the discovery learning model (Sari et al., 2023). It can be seen that chemical literacy in the guided inquiry model with the flipped learning approach has an average n gain of 0.252 higher than the n gain in the discovery learning model. A comparison of students' pretest and post-test scores is shown in the Figure 1.

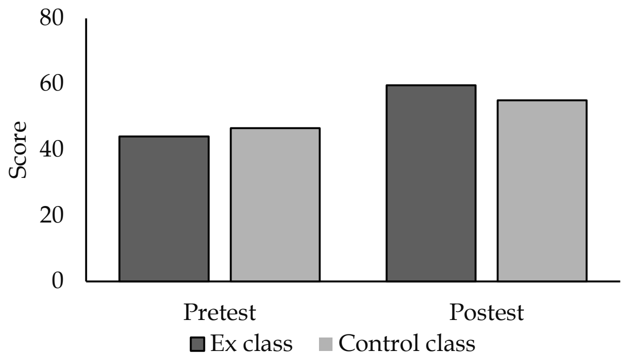

Figure 1. A comparison of students' pretest and post-test scores

Effective Contribution to Implementing Guided Inquiry Learning with a Flipped Learning Approach in Improving Science Process Skills and Chemical Literacy

The application of guided inquiry with a flipped learning approach to science process skills and chemical literacy simultaneously is the focus of this research. The MANOVA test had a significant influence on science process skills and chemical literacy simultaneously. The guided inquiry model with a flipped learning approach provided an effective contribution of 29.70%. The percentage shown indicates that there is an influence of the application of the guided inquiry model with a flipped learning approach on science process skills and chemical literacy, although with sufficient value (Irwanto et al., 2024).

One of the factors that influences effective contributions is the reliability of research instruments. A good measuring tool can make a large effective contribution. In this study, the reliability of the instrument reached a value of 0.466, which is included in the sufficient criteria (Duli, 2019). This means that the measuring tools or research instruments prepared are sufficient to explain the relationships and differences in variables so that sufficient effective contributions are obtained.

The second factor, students are actively involved in taking part in reaction rate experiments. Each group plays a role in finding concepts in the experiments carried out. Basic science process skills that are visible during experiments are observing, classifying, measuring, and predicting. Two other skills, namely communicating and concluding, can be seen in the students' presentation process in front of the class. Therefore, laboratory experiments can improve science process skills because students can optimally search and find answers by being directly involved (Rahmawati & Haryani, 2014).

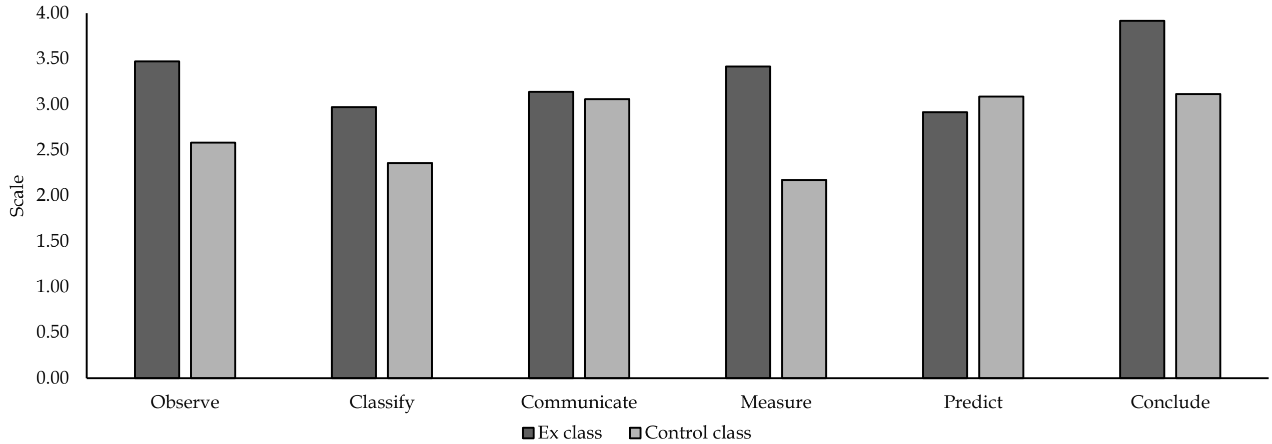

Figure 2. Comparison of basic science process skills for experimental and control classes

From figure, the second factor is the application of practical work in the laboratory which is related to daily life. Students experience meaningfulness in learning making it easier to understand the material and open up insights regarding phenomena in their environment (Fakunmoju et al., 2016). Learning by applying practicum is an alternative that helps students learn actively to reconstruct their conceptual understanding (Andayani et al., 2018). Students understand that the speed of a reaction is influenced by various factors. Examples of reaction rates relate to everyday life such as cutting meat when cooking and the role of yeast in making bread. Every skill in the experimental class science process skills is higher than the control class. The skills of concluding, observing, and measuring are skills that show high student abilities compared to other skills.

The application of the guided inquiry learning model with the flipped learning approach shows an increase in the chemical literacy and science process skills of students. The guided inquiry model encourages students to plan and conduct experiments, collect, analyze data, and draw conclusions related to problems so that students' process skills increase (Budiyono & Hartini, 2016). Learning materials using the guided inquiry model are effective in improving students' science literacy (Faradilla & Hasan, 2018).

Conclusion

Data analysis using MANOVA revealed significant differences and effects between the guided inquiry-flipped learning and discovery learning models, with an effective contribution of 29.70%. These findings highlight the positive influence of the guided inquiry and flipped learning approach on enhancing science process skills and chemical literacy.

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Author Contributions

Conceptualization, N. T., and S. A.; methodology, N. T., and S. A.; validation, N. T.; formal analysis, S. A.; investigation, N. T.; resources, N. T.; data curation, N. T.; writing—original draft preparation, N. T., and S. A .; writing—review and editing, N. T., and S. A; visualization, S. A. All authors have read and agreed to the published version of the manuscript

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Conflicts of Interest

The authors declare no conflict of interest.

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