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The Correlation Between Improving Self-Regulated and Students' Conceptual Understanding of Colloidal Topics Using POGIL Approach

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Abstract: Bland learning is one of the causes of students' inability to explore freely by prioritizing self-regulated in each learning process. The POGIL model is an approach that makes students free to explore every step of the learning process with the teacher serving as a helpful facilitator. This research aims to look at the correlation between increased self-regulated and conceptual understanding in colloidal material with the POGIL model. The increase that occurs does affect each other. The results in this study experienced an increase in conceptual understanding, with a mean of 70.09 in the experimental group and 51.21 in the control group. At the same time, the increase in the value of students' self-regulated was 84.59 in the in the experimental group and 72.37 in the control group. Pearson product-moment correlation analysis was obtained at -0.243. This study concludes that learning using the POGIL model effectively increases learning self-regulated and conceptual understanding. The correlation of these two variables is interpreted as a negative correlation or an indirect relationship (inverse).

Keywords: POGIL; Self-regulated; Conceptual Understanding; Correlation

Introduction

Science learning is not just scientific knowledge, encapsulating various facts, concepts, laws, and theories that become a scientific study through the process of scientific activity itself (Malik, 2015). The constructivist learning method allows students to practice process skills, improve cognitive capacities independently, and breed a positive mindset (Razak & Kamaruddin., 2018). This process provides an opportunity for students to develop thinking skills and develop a scientific attitude. The science includes a group of knowledge about items and living beings, as well as how they work, think, and solve a problem by formulating hypotheses, designing and carrying out experiments, processing data, and communicating results (Rengganis & Dwijananti, 2015).

The development of scientific attitudes in schools must be balanced with students' cognitive development level. Learning outcomes are directly proportional to the level of learning independence and the cognitive nature of students (Razak & Kamaruddin., 2018). The scientific attitude becomes a general assessment of an object related to science through discussions, experiments, simulations, and project activities of students who can develop a scientific attitude (Dwi Apriliani et al., 2019). Applying knowledge as a means of identification is commonly observed in evaluating scientific aptitude (Septianti et al., 2022).

Several learning models have been applied to the learning process, which has their respective advantages and disadvantages in how students can develop according to the learning model's treatment. However, in this case, a learning model prepares students to be free to do their experiments by seeing what happens, doing something they want, asking questions, looking for answers on their own, and connecting findings

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according to Piaget's theory regarding the inquiry learning model (Haerullah & Hasan, 2017). The inquiry learning model is an educational approach to enhance students' independence and efficiency in conceptual understanding. One of the inquiry learning models used is the Process Oriented Guided Inquiry Learning (POGIL) model, which directs students well. The POGIL model does not only emphasize content mastery from a scientific discipline, but process skills become an immediate focus in improving students' cognitive. The relationship between the two main components, namely process-oriented and guided inquiry (Datu-Dacula & Anda, 2021).

Process-oriented, which assigns students to form a team that has its role in the team. The POGIL model gives students a positive role in team success (Vanags et al., 2013). The POGIL model is applied so that students are more structured in solving problems and understanding material concepts in the learning process. The POGIL model cycle has several stages: orientation, exploration, concept formation, and application (Zumronah et al., 2019). The teacher's role in this learning model is critical as a facilitator, monitor, and evaluator of student learning processes (Barthlow & Watson, 2014).

Self-regulated learning was initially seen as a stable and non-contextual individual characteristic. Various developments of new conceptualizations to see the potential for independent learning use approaches from various methods depending on the dynamics of the activity (Endedijk et al., 2016). Improving academic achievement, learning motivation, and students' self-confidence during the learning process can be increased by independent learning (Meyer et al., 2008).

Chemistry lessons involve a variety of mathematical calculations, but colloid learning materials involve few mathematical calculations. Every day cannot be separated from colloid system material that can be applied to personal needs. Therefore learning material for the colloid system is essential (Damanik & Yanny, 2016). Comprehending colloidal material, students usually only memorize and often need to concentrate and think this material is boring. An active learning model is one way to attract students' interest in increasing their conceptual understanding of colloidal material. The cooperative learning model is considered capable improve students' conceptual understanding skills (Ulya et al., 2012). Instruct for info regarding guidelines for learning the methodology employs a pedagogical approach in which the instructor introduces a sequence of guiding inquiries and explore students' ways of thinking to be creative students' thinking processes toward new knowledge being studied.

Students' weak scientific literacy skills indicate a weakness in their higher-order cognitive abilities and reasoning techniques. The development of higher-order thinking skills and mental strategies is not achieved by direct instruction but through training within the learning process. So the factors contributing to students' limited scientific literacy proficiency may arise from several sources, such as teachers, the quality of learning and teaching, students themselves, and facilities and infrastructure (Mellyzar et al., 2022).

Previous research conducted many correlation analysis tests on the variables being measured. Correlation is a statistical test that states the degree of linear relationship between two or more variables. Researchers often use the correlation to connect one variable and another using the moment product correlation. This correlation was discovered in the early 1900's by Karl Pearson. Product moment correlation states the magnitude of the contribution of one variable to another and is expressed in percent. Then r_2 is called the coefficient of determination or the determining coefficient. Value limit r $-1 < r < +1$. If $r = +1$, then the relationship is perfectly positive, linear, and the interpretation is very high. Conversely, if $r = -1$, it is called a perfect negative relationship, and the relationship is indirect or inverse (Usman & Akbar, 2008).

Method

This study employed a nonprobability sampling approach, explicitly utilizing a purposive sampling technique based on the characteristics of student learning outcomes. The experimental and control classes were taken and given a pretest and posttest, consisting of a self-regulated learning questionnaire and a conceptual understanding test. The method for interpreting this research utilizes quantitative with the help of SPSS IBM 23.

Data is collected using several methods, such as observation, answer questionnaires, and testing—verifying the quality and effectiveness of student worksheets and lesson plans through professional evaluation. The implementation of various methods is proposed as a means for dealing with students' diverse backgrounds, with the ultimate goal of enhancing their comprehension and grasp of conceptual knowledge (Nur'aini et al., 2023).

A Likert scale was utilized in the development of a self-regulated answer questionnaire. Quantitative analysis was conducted on the data. Quantitative data analysis determines the efficacy of validity, enhancement, and validity testing. The pretest and posttest findings were subsequently analyzed

employing the N-gain test. The N-gain value is determined by utilizing the following formula while being directed by parameters modified from previous sources (Hake, 1998).

$$N_{gain} = \frac{S_{posttest} - S_{pretest}}{S_{max} - S_{pretest}} \quad (1)$$

Table 1. N-gain Value Criteria

Gain	Criteria
(g) ≥ 0.70	High
0,30 ≤ (g) < 0.70	Medium
(g) < 0.30	Low

Correlation analysis to calculate the value of r. if r = +1, the correlation between the two variables is linear and positive at very high. If r = -1, the correlation between the two variables is linear, negative, and very high. To interpret the r value obtained in this study, see Table 2.

Table 2. Criteria of Correlation

Size of Correlation	Interpretation
0	Uncorrelated
0.01 – 0.20	Very weak
0.21 – 0.40	Weak
0.41 – 0.60	Rather Low
0.61 – 0.80	Sufficient
0.81 – 0.99	High
1.00	Very High

The learning cycle is characterized by a three-phase structure consisting of the exploration, concept invention, and application phases (Şen et al., 2016).

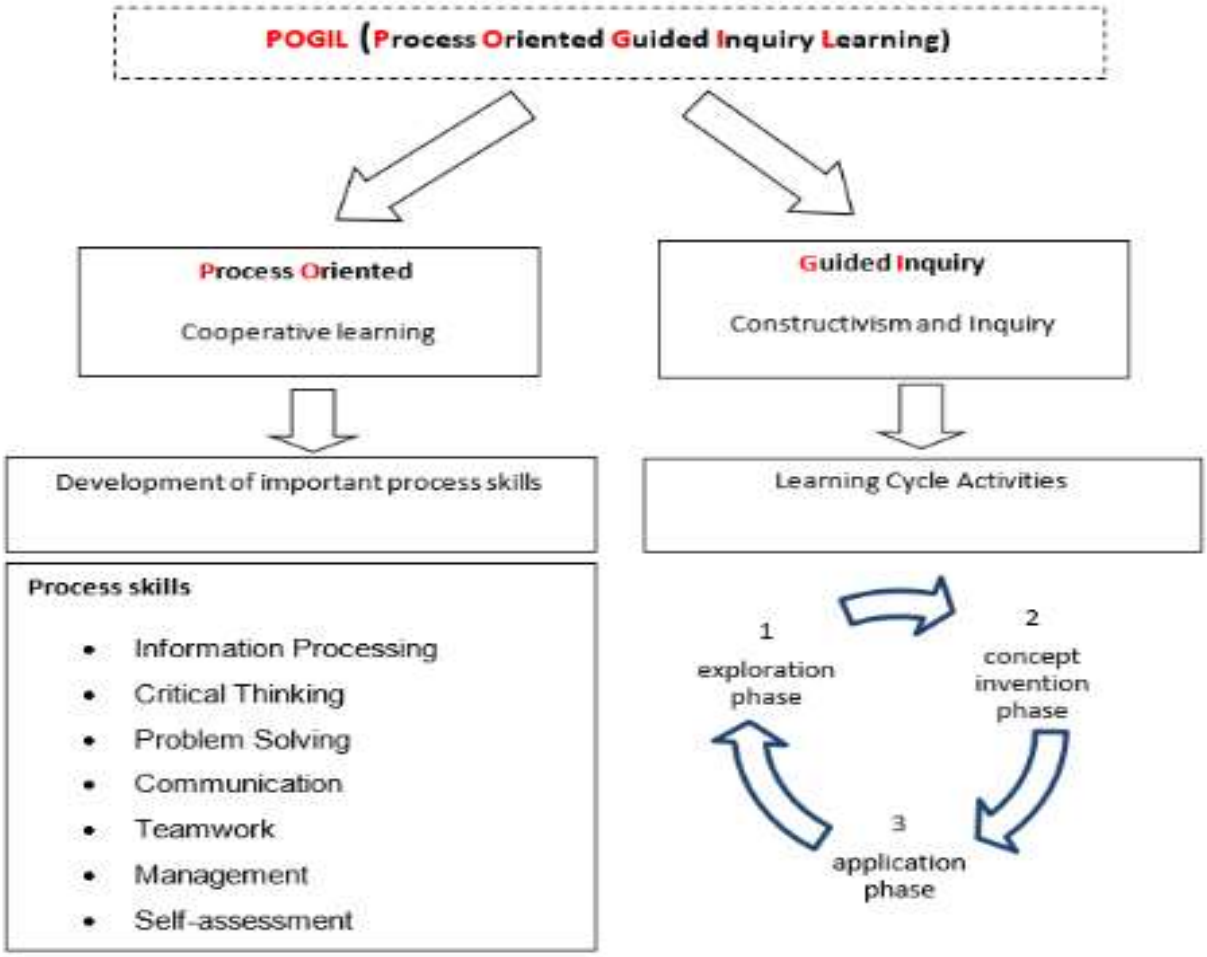

Figure 1. The Learning Cycle in POGIL (Şen et al., 2016)

The teacher's role in POGIL is as a learning facilitator for each student. The teacher does not directly intervene in the group. The teacher is only involved in the group when the group asks for direction or discussion regarding the material and ensures that their scientific opinion is a well-structured concept. All of these phases are actualized based on the learning cycle at POGIL (Şen et al., 2016).

Result and Discussion

Students' understanding of the concept in terms of the pretest and post-test questions given in the learning process. Increased understanding of the concept regarding the colloid topic with as many as 20 pretest and post-test questions. The results of validating the concept comprehension test questions include aspects of competence, feasibility, content, and content of the 30 questions validated by experts. 20 questions are good and are implemented for research to measure conceptual understanding. The pretest and post-test values of the experimental and control classes were analyzed to determine whether there was an increase in students' conceptual understanding before and after implementing the POGIL model in the learning process. The tabulation of pretest and post-test scores can be seen in Table 3.

Table 3: Interpretation of Pretest and Posttest Scores for Conceptual Understanding

Class		Mean	t-test	N-Gain (%)
Experiment	Pre	22.92	Sig (2-tailed)	60.90
	Post	70.09		
Control	Pre	23.17	0.000	36.18
	Post	51.21	<0.05	

Based on the results of the interpretation of the scores from the pretest and posttest about understanding the concepts that have been tested with the help of SPSS23, it shows that the average score of the experimental class in the pretest is 22.92, which shows that students' understanding of the colloidal material concept is still low. The POGIL model is carried out during the learning process by dividing into groups and providing space for students to design treatments independently on worksheets and look for trusted sources of information on each material's properties by colloidal material. The treatment of the posttest after the learning process was completed by getting a result of 70.09, which indicated an increase in conceptual understanding of colloidal topics. These results are supported by research conducted by Sarwi et al. (2019), which states that guided inquiry applies character values to each process. An increase in conceptual understanding is one of the factors due to the positive impact of sharing with other group members and discussing to find the best answer. Guided inquiry experiments are of outstanding value for supporting independence and helping a greater comprehension of the subject matter through immediate participation (Sarwi et al., 2019).

The difference in educational achievements was observed between the pretest and posttest results from the applied treatment (Khairini et al., 2021). Individuals with a higher level of cognitive ability possess diverse cognitive skills and methods that empower them to systematically and efficiently tackle difficulties. Individuals can examine intricate circumstances critically, discern recurring trends, and devise innovative resolutions. Individuals can utilize their existing knowledge and past experiences to generate creative methods and adjust their problem-solving techniques to various situations. Advanced education, training, and expertise are frequently linked to higher cognitive capacities (Hulyadi et al., 2023).

In a learning environment, teachers have avoided implementing worksheet and a teaching model based on Process Oriented Guided Inquiry Learning (POGIL) to students due to the many challenges associated with this particular instructional approach. Encouraging student engagement can be challenging as not all pupils exhibit high activity levels. POGIL is an instructional approach that prioritizes student-centered pedagogy, encouraging active student engagement in learning activities and fostering a deeper exploration of subject matter (Septianti et al., 2022)

The next test was conducted by testing the hypothesis using a paired sample t-test with a sig level of > 0.05. Prerequisites to determine whether the pretest and posttest are typically distributed. The experimental group exhibits a greater level of achievement compared to the control group. The normality of the pretest data was assessed using the Shapiro-Wilk test, revealing statistically significant results 0.373 > 0.05 and posttest 0.314 > 0.05, so it was concluded that both data were normally distributed and hypothesis testing could be carried out. Test the paired sample t-test with the help of SPSS23 to determine the difference in the significance of understanding the concept before and after implementation using the POGIL model. Based on the data outlined in Table 1, a statistically significant (2-tailed) p-value of 0.000 was found, which suggests a significance level below the commonly accepted threshold of 0.05. The results of this research indicated a statistically significant disparity between the pre-implementation and post-implementation phases of the students.

Research to see an increase in self-regulated learning and conceptual understanding is also supported by research conducted by (Cascolan, 2019) by looking at increases between 3 variables, namely conceptual understanding, metacognitive, and independent learning with the POGIL model—good correlation between increases in 3 variables and positive results.

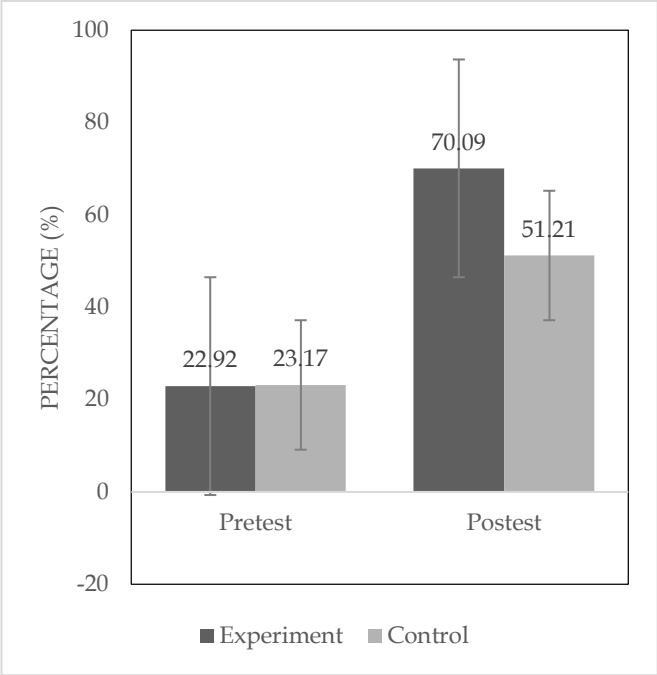

Figure 2. Conceptual Understanding Test Results

The present study demonstrates a statistically significant disparity between the outcomes of the t-test and the average score, indicating that implementing the POGIL model has a notable impact on the attainment of conceptual comprehension. The results made the POGIL model effective and very good during the learning process. This research conducted by (Datu-Dacula & Anda, 2021). The POGIL model in the learning process makes students more active and happier. Because students get the opportunity to investigate directly what to do, material that makes students more curious about everyday life (Aiman et al., 2020). In addition, students are motivated during the learning process, with practicum carried out during the learning process. The theory they understand is not with a lengthy explanation but with the practicum they do concerning the types and properties of colloids. It makes students more independent, skilled, have scientific abilities, and actively solve problems (Hu & Shepherd, 2014).

Based on the implementation of the POGIL model in the learning process towards student learning independence by using a questionnaire developed by Hidayati & Listyani (2010) with six indicators which include; (a) independence from others, (b) having self-confidence, (c) having discipline, (d) having a sense of responsibility, (e) acting on one's initiative, (f) exercising self-control. Questionnaires were given before and after the implementation of the learning model. The study used the average pretest and posttest scores from each experimental and control group, as displayed in Table 4.

Table 4. Interpretation of Pretest and Posttest for Self-Regulated

Class		Mean	t-test	N-Gain (%)
Experiment	Pre	66.67	Sig (2-tailed)	50.83
	Post	84.59		
Control	Pre	67.19	0,000	15.36
	Post	72.37	<0.05	

Based on Table 4, the average score obtained for the independent learning questionnaire of students using the POGIL model in the experimental class and DI in the control class with three sessions. The pretest score in the experimental class was 66.67, which was categorized as sufficient. The increase in learning independence during the learning process with the POGIL model was seen from the post-question learning independence of 84.59 in the experimental group. In comparison, the control with DI showed an increase of 67.19 in the pre-and 72.37 post-question. The worksheet on the efficacy of instructional materials created by researchers can be determined by evaluating the extent to which students' comprehension of concepts improves, as indicated by the results of the N-Gain test administered before and after the instructional intervention (Herayanti et al., 2022).

The experimental class shows significant improvement. The difference in student learning independence is due to an active learning model, so students become challenged during the learning process. The positive side of the learning model is that it makes students active, makes students understand about making decisions, and controls themselves in thinking so that independence when learning goes well (van Hout-Wolters et al., 2000).

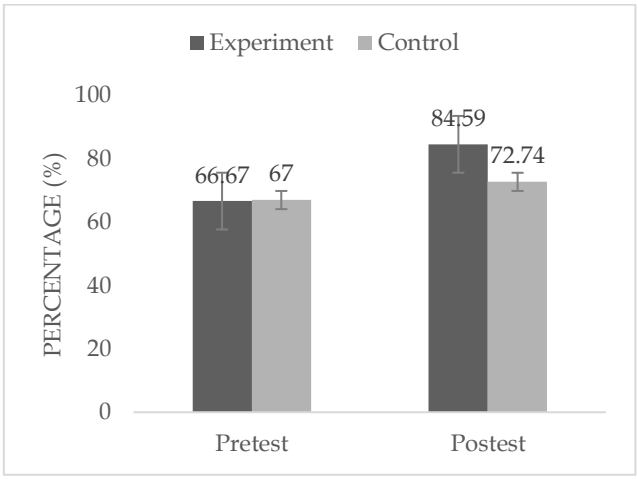

Figure 3. Self-Regulated Test Results

Self-regulated learning students instill in the learning process requires expressing themselves and looking for what they do not know under the teacher's supervision. As a facilitator, the teacher intervenes when

students have questions that help the team design an experiment. Students will experience difficulties during the first meeting, but if the facilitator, namely the teacher, can direct students, the improvement and progress in the learning process using the POGIL model will be better (Cascolan, 2019).

The hypothesis analysis on the increased learning independence was conducted using the paired sample t-test at a significance level 0.05. The Shapiro-Wilk test was conducted to assess the normality of the data. The results indicated statistical significance, with a value of 0.168 more significant than the predetermined alpha level of 0.05 in the experimental group and 0.536 greater than 0.05 in the control group, so it was concluded that both data were normally distributed and hypothesis testing could be continued. Based on Table 2 above, the sig.(2-tailed) value is 0.000 <0.05, so; H_0 was rejected, and H_a was accepted, so it was concluded that there was a significant difference between students' learning independence before and after implementing the POGIL model. Students' abilities in each indicator are measured as indicators of learning independence. In constructivism theory, students have ideas and independent knowledge about the environment and various other events.

One of the reasons for the increase in self-regulated is active learning to increase the effectiveness of students. Active learning is also essential for teachers to be more motivated if students are more curious and independent learning is more active. In addition, teaching becomes more challenging to answer curiosity questions from students whose learning process is more active (van Hout-Wolters et al., 2000). The framework for strengthening creative thinking skills, such as fluency, flexibility, and originality, lies in favorable learning settings and ample opportunities for self-expression (Feranie et al., 2023). Implementing self-regulated learning phases within the framework of guided inquiry syntax may potentially stimulate the development of students' creative motivations. The experimental class exhibited more progress in the interested and discipline domains than the control class, which only showed improvement in the discipline area (Algiani et al., 2023).

The correlation test is a statistical procedure employed to quantify the association between two or more variables insofar as the variables are related to one another so that other changes accompany changes that occur (Madden et al., 1991). This study calculates the correlation value to see whether there is a relationship between the increase in the value of self-regulated and conceptual understanding. Correlation data between the two variables can be seen in Table 5.

Table 5. Product Moment Colleration

Variable	Pearson Correlation	Sig (2-tailed)
Self-Regulated Conceptual Understanding	-0.243	0.223

The data showing the Pearson correlation of learning independence and understanding of concepts assisted by SPSS23 shows the indicated value of -0.243, and p is 0.223. A negative correlation value concludes from this data a correlation that does not imply the two variables move in the other direction. If one variable increases, the other variable decreases with the same significance. The correlation is negative, similar to the positive correlation. Various influences will influence the correlation, although negative correlations receive far less attention in research. In a negative correlation, the values of the other variables tend to decrease and plot pairs of variables in opposite directions simultaneously (Li et al., 2010). The correlation value tested can be seen in Table 6.

Table 6. Correlations of Self-Regulated and Conceptual Understanding

		Self-Regulated	Conceptual Understanding
Self-Regulated	Pearson Correlation	1	-0.243
	Sig (2-tailed)		0.223
	N	27	27
Conceptual Understanding	Pearson Correlation	-0.243	1
	Sig (2-tailed)	0.223	
	N	27	27

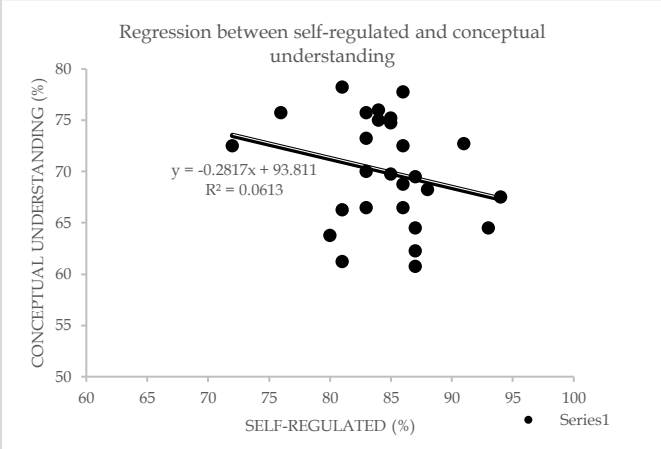

Figure 4. Regression Between Self-Regulated and Conceptual Understanding

Table 7. Results Linear Regression Analysis

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	43.36859975	43.3686	1.632554	0.213088
Residual	25	664.122141	26.56489		
Total	26	707.4907407			
Summary Output					
Multiple R	R Square		Adjusted R Square	Standard Error	Observations
0,247587	0.0612992		0.0237511	5.1541135	27

A simple linear regression analysis in Table 7 was conducted to predict self-regulated outcomes employing conceptual understanding as the independent variable. A regression analysis was conducted, resulting in a significant regression equation with an F-value of 1,6326 and an R-squared value of 0.0613.

Conclusion

Based on the results of the research that has been done about the use of the POGIL for improving self-regulated and conceptual understanding in Colloidal topic, it can be concluded that It can improve conceptual understanding and sefl-regulated. It is evidenced by the results of the N-gain experimental class obtained an average understanding of the concept of 60.9%. The N-gain results for the experimental class obtained an average of 50.83% self-regulated. The results of testing hypothesis H_0 were rejected, and H_a was accepted so that it was concluded that there were significant differences before and after the application of the POGIL model. The Pearson self-regulated correlation score and SPSS23-assisted conceptual understanding were obtained at -0.243. The regression obtained is $R^2 = 0.0613$. Negative correlation values infer from this data a correlation that does not imply the two variables move in the other direction.

Author Contributions
APU becomes lesson plans, concepts, ideas, observations, conducting research, reproducibility of results, and data collection. MH and MA are supervisors in this research and have reviewed and monitored the research progress. EE as a validation instrument for learning plan data. All the author has read and agrees to the published version of script

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Conflicts of Interest
The authors declare no conflict of interest.

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