Asian Journal of Applied Education (AJAE)
Vol. 4, No. 2, 2025: 145-160

Optimizing Cognitive Learning Outcomes in Earth Science Through Online Process-Oriented Guided Inquiry Learning

Ricardo F. Uy[1]*, Andrea G. Azuelo[2]
Science Education Department, Central Mindanao University
Corresponding Author: Ricardo F. Uy, s.uy.ricardojr@cmu.edu.ph

A R T I C L E I N F O

Keywords: Cognitive Learning Outcomes, Earth Science, O-POGIL

Received : 25, March
Revised : 8, April
Accepted : 22, April

A B S T R ACT

This study examined the effects of online Process Oriented Guided Inquiry Learning (O-POGIL) on students' cognitive learning outcomes in Earth Science. A one-shot pretest-posttest pre-experimental design was employed in the study. The reliable teacher-made test and an adapted academic self-concept survey questionnaire were the instruments used. Descriptive statistics, paired t-test and one sample t-test was used for statistical data analysis. Findings of the study revealed a satisfactory cognitive learning outcomes of students as exposed to O-POGIL. Further results indicated statistically significant difference on students' cognitive learning outcomes on their pretest and posttest. Significant difference existed between students' cognitive learning outcomes and the existing competency standard.

DOI prefix: https://doi.org/10.55927/ajae.v4i2.14101
ISSN-E: 2963-5241
https://journal.formosapublisher.org/index.php/ajae

INTRODUCTION

Cognitive learning is an indicator that evaluates the quality of science education and is measured through examinations or continuous assessments. It relates to students' measurable level of academic achievement and the quantifiable result of intellectual effort in various educational activities (Shi et al., 2019). The assessment of cognitive learning outcomes depends on students' development and the effectiveness of educational approaches. Moreover, a student-centered approach is crucial in promoting learner's cognition and improving scientific skills (Lestari et al., 2018).

In the Philippines, science education aims to equip students with the knowledge and skills to think critically and solve complex problems. However, this goal is impeded due to student's poor cognitive learning outcomes. The state of Filipino students' poor learning outcomes in science is evident in the National Achievement Test (NAT), Trends in International Mathematics and Science Study (TIMSS), and the recent Programme for International Student Assessment (PISA) results. In PISA 2022, the country obtained an average scientific literacy score of 356 points, significantly lower than the standard score of the Organization of Economic Co-operation and Development (OECD), 485 points (OECD, 2023). The scientific literacy of the Philippines falls behind that of the ASEAN countries that participated. This is quite alarming to note about studies on cognitive learning outcomes. With this regard, teaching approaches should be developed and applied to meaningful and retentive science learning (Andarino, 2019).

Process-oriented guided inquiry learning (POGIL) integrates cooperative and inquiry-based learning, which enhances students' cognition (Sen & Yilmaz, 2015). It is based on the social constructivist approach in which students work on activities mainly designed to help them grasp key concepts and practice important abilities (Kussmaul & Pirmann, 2021). The activities included enable learners to respond to inquiries by prioritizing evidence, formulating explanations based on the evidence, connecting those explanations to scientific knowledge, and then applying those explanations. Teachers become facilitators who model the learning process and support students in processing information (Zgraggen, 2018).

Research studies recommended the implementation of process-oriented guided inquiry learning as it improves students' cognitive learning outcomes. However, previous studies were conducted face-to-face, where teachers could direct instruction inside the classroom. There are limited studies on the application of POGIL in online learning environments. Thus, the Department of Education (DepEd) and the Commission on Higher Education (CHED) suggested strengthening online learning platforms such as Google Classroom, Edmodo, and Zoom (Tria, 2020). More so, students become dynamic in learning if they can use the online world as an avenue for learning (Aderibigbe,2020). This paved the way for educators to consider integrating an online teaching approach that enhances students' cognitive learning. Thus, this study examines the effects of the online POGIL approach on students' cognitive learning in Earth Science.

Research Questions

1. What is the students' cognitive learning outcomes in relation to their pretest and posttest as exposed to online process oriented guided inquiry learning approach?
2. Is there a significant difference on students' cognitive learning outcomes in relation to their pretest and posttest as exposed to online process oriented guided inquiry learning approach?
3. Is there a significant difference on students' cognitive learning outcomes to the existing competency standard?

LITERATURE REVIEW

Students' Cognitive Learning Outcomes in Science

Science education aims to investigate how students learn science, what best practices teachers may use, and how to adapt new teaching strategies to improve learning outcomes (Uy & Tan, 2025). Cognitive learning is a change in knowledge that was driven by experience. This include three components such as learning involves a change, the change is in the student's knowledge and the cause of the change is the learners experience. It can be distinguished from behavioral learning on the basis that cognitive learning involves a change in student's knowledge whereas behavioral learning involves a change in the student's behavior. It explains the process of learning in terms of prior knowledge, where new information must be connected.

According to Kisworo and Gusman (2019), students' cognitive learning outcomes and critical thinking skills are better when POGIL was employed as a teaching strategy. It was noted in the study of Idul and Caro (2019) that students under POGIL method had improved their performance and process skills in science. A study evaluating the influence of the POGIL approach on students' academic performance in Physics found a substantial difference in students' academic performance when compared to those who were not exposed to the POGIL approach (Bug-os & Caro,2019). Similarly, a study found that using the POGIL technique would enhance students' overall exam performance, improve higher-level thinking skills, and offer an engaging classroom environment (Soltis et al., 2015).

Process Oriented Guided Inquiry Learning Pedagogy improved students' academic achievement in scientific education (Udu & Uwaleke, 2020). As indicated, students who studied through the POGIL approach had a better understanding of the content knowledge than those who learned through lecture. Lestari et al. (2018) found that guided inquiry learning model application had a substantial impact on students' cognitive accomplishment in the concept of Stoichiometry. As noted, participants under POGIL pedagogy had a higher likelihood of graduating a course and fared better on achievement indicators than those in traditional lectures (Walker & Warfa, 2017).

Purkayastha et al. (2019) revealed that there is a statistically significant difference in the performance of students before and after implementation of POGIL. POGIL approach increased student overall performance on examinations, improved critical thinking skills, and provision of an interactive

class environment. It positively impacts the students to have better understanding on the content knowledge in science subject. That students' cognitive learning outcomes and critical thinking skills are better when POGIL is employed as a teaching strategy. This is consistent with the findings of Vacek (2011) which concluded the notable change in the students ’performance upon investigation on the effectiveness of POGIL as a teaching approach for Physical Sciences. However, the study of Roller (2015) revealed no significant difference on grade performance when POGIL method was employed.

Significant findings were noted by Irwanto et al. (2016), that students had shown a very good performance in problem solving during the course process and various questions were raised at the end under POGIL method. Another study was found certain that student significantly increased their performance as exposed to POGIL environment (Ucang & Tan, 2013). The same employment on the use of POGIL by Ratti and Power (2018) was able to observe the increase of students’ performance from 54% to 85% approximately in the first semester. The use of POGIL instruction is significantly better in enhancing students’ academic performance compared with the traditional method (Villagonzalo, 2014).

As a learning group, students are able to utilize the dynamic online world as an avenue to construct knowledge, communicate, argue, and to solve or answer a certain science problems or situations. Hudson (2019) found that students achieved a high learning outcome after being exposed to POGIL approach. Furthermore, students exposed to POGIL class acquire critical and analytical thinking skills, cognitive learning strategies that are considered significant learning outcomes (Tran & Lamar, 2020). However, Vanags et al. (2013) reported that students exposed to POGIL had a low posttest score.

Online Implementation of POGIL

Many institutions changed from traditional face-to-face learning to flexible learning in response to the COVID-19 pandemic in the new normal education. Several online approaches have been used as part of the mode of delivery, giving students the opportunity to learn through online engagement. The use of multimedia like videos have impact to learner’s knowledge building. According to Reynders and Ruder (2020) students prefer pre-recorded and YouTube videos before POGIL live sessions through Zoom as it offers learners with background information and a basic comprehension of the topic. A study conducted through computerized Experimental Psychology Laboratories employing POGIL indicated that student’s achieved better results than students who did not use POGIL (Rumain & Geliebter, 2020).

The current health crisis has changed how teachers perceived their courses particularly the synchronous class time with students. However, some teachers have discovered a beneficial way for students to have collaborative learning during synchronous instruction. Working together in ZOOM breakout rooms better engages students in course content (Hu & Kussmaul, 2021). It also builds a sense of community where students can actively involve themselves in the learning process. However, this may present additional concerns for students with poor internet access or other constraints. Success in online

collaborative learning implementation requires more structure than in face-to-face set up.

In teaching, an online environment creates teamwork and interpersonal skills because learners are restricted to their homes with little face-to-face interaction. One of the concerns is getting everyone to participate and ensuring that everyone is contributing to the team (Myers et al., 2014). Those mentioned concerns can be addressed through POGIL, as it encourages active learning, collaboration, and knowledge generation in both online and face-to-face settings. Sanggara et al. (2018) investigated the problem solving of learners in the Virtual Laboratory through POGIL and found out that students' physics problem-solving ability was enhanced.

Noopur and Siu-Kit (2021) reported that students' online learning outcomes were high after the implementation of POGIL. When POGIL was used as a pedagogy, this improved the students' learning experiences, commitment to the class either individually or in groups, and received an overall high course grade. It was found by Artuz and Roble (2021) that students critical thinking was enhanced after they were taught using online POGIL.

Novelty of the Study

While numerous studies have validated the effectiveness of Process-Oriented Guided Inquiry Learning (POGIL) in enhancing students' cognitive learning outcomes, most of these investigations have been limited to traditional face-to-face settings. The transition to online learning, especially prompted by the global shift in educational modalities, presents a unique challenge and opportunity to examine the applicability of POGIL in virtual classrooms. There remains a significant gap in empirical research exploring how online POGIL can influence cognitive learning, particularly in the context of science education in the Philippines. Given the persistent underperformance of Filipino students in international assessments like PISA and TIMSS, this study offers a timely and innovative exploration into how an online POGIL approach can be strategically employed to address deficits in scientific literacy. By focusing on the Earth Science subject that integrates conceptual understanding and real-world application, this research provides valuable insights into pedagogical innovations that can be adopted in digitally mediated learning environments.

METHODOLOGY

Research Design

The study utilized the one-shot pretest-posttest pre-experimental research design to determine the effects of an online process-oriented guided inquiry learning approach on the cognitive learning outcomes of Grade 9 Earth Science students at Central Mindanao University Laboratory High School.

Implementation of Online Process-Oriented Guided Inquiry Learning

For the implementation of an online process-oriented guided inquiry learning approach. This study utilized the 7E's of learning integrated with the Explore-Invent-Apply learning cycle. The implementation of online POGIL was

patterned with a few modifications from Trevathan and Mayers (2013) and Artuz and Roble (2021). In the context of this study, an online process-oriented guided inquiry learning approach was implemented with the following steps:

Pre-online POGIL approach implementation started with orientation. In this phase, orientation was given on the roles of both the teacher and the learners and the nature of the activity. It followed an orientation about the functions, applications, and features of the Zoom Meeting App. Another pre-online implementation of the POGIL approach was distributing the POGIL activity sheet. The teacher uploaded the POGIL activity sheets to Google Classroom for students to download. The guided inquiry worksheets were based on the core phases of the Explore-Invent-Apply Learning Cycle. The worksheets were constructed to expose students to the online POGIL approach with fewer lectures and more student collaboration.

Elicit. To elicit their prior knowledge, students were asked pertinent questions about the topic. A short video about the lesson was presented to capture their interest. They were acquainted with the learning objectives, which guided them throughout the learning process.

Formulation of Group. Students were divided into groups of 4-5 members. Each student had a specific role to play within the group. The roles that were given to students were manager, recorder, reflector, presenter, and technician. Then, they were brought to their respective Zoom breakout rooms.

Exploration Phase. In this phase, the students analyzed the information in the POGIL activity sheet through group discussion. The observations and analysis of illustrations or data were made during this phase. Students are to generate hypotheses about the concept or model under study. The uncertainty in students became lower since the guided inquiry questions were embedded in the POGIL activity sheet.

Concept Invention. In this phase, the students described or explained the observations made in the exploration phase. After the students expressed their own understanding, the teacher introduced conventionally related terminology. Deductive reasoning skills were needed since they connected the general concepts from the previous phase to new situations. The POGIL activity sheet guided students to develop more concepts relevant to the model being studied.

Application Phase. In this phase, students worked independently with minimum assistance from the teacher. During concept application, students were given problem situations that confronted their initial observations. Application in this context encompasses analyses, syntheses, and evaluations.

Evaluation. After the students answered the POGIL activity sheets, both traditional and performance-based assessments were utilized to measure their learning and check whether the expected learning outcomes were achieved.

Extend. They were tasked with extending the concepts and skills in new but similar situations through assignments to deepen students' understanding.

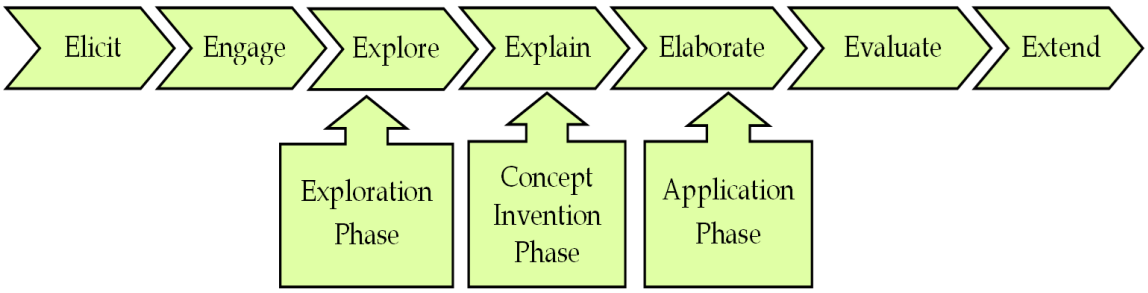

Figure 1. Implementation of O-POGIL in Earth Science Class

Instrumentation

Percentage Equivalent	Performance Level	Qualifying Statement
90-100	Outstanding	Exceeds the core requirements in terms of knowledge, skills and understanding can transfer them automatically and flexibly through authentic task.
85-89	Very Satisfactory	Develop the fundamental knowledge, skills, and understanding and can transfer them automatically and flexibly through authentic performance.
80-84	Satisfactory	Develop fundamental knowledge and with little guidance from the teachers and /or with assistance from peers, can transfer these understanding through authentic performance.
75-79	Fairly Satisfactory	Possess the minimum knowledge, skills, and understandings, but needs assistance.
74 below	Did Not Meet Expectation	Struggles with his/her understanding, pre-requisites and fundamental knowledge and skills have not been acquired or developed adequately to aid understanding.

The study utilized academic assessment, forty (40) items multiple-choice test was used. The test items were validated by a panel of experts in Earth Science to determine its appropriateness in testing cognitive learning outcomes. Reliability test was conducted after it was field tested to Grade 10 classes of CMULHS. Using Pearson Reliability Test, it was calculated that the Cronbach alpha of the test questionnaire was 0.80, which means good and reliable for classroom test. To determine the level of students' cognitive learning outcomes as exposed to online POGIL approach the following indicators was used based on DepEd Order No. 8 series of 2015.

Data Gathering Procedure

A letter of permit was requested from the office of the principal to get approval to conduct the research study. When the permit was obtained, the researcher purposely selected the Grade 9 class based on their learning modality and student characteristics. Informed consent was given to ensure that students were well-informed about the nature of the study. The researcher

oriented the students on how the online POGIL approach was implemented. The group was given the pretest before the experimental period started.

The experiment was conducted during the second grading period, considering that Earth Science was the subject of focus for this quarter. In the group, the integration of the Online POGIL approach was used as the instructional approach, which includes different forms of instructional materials such as POGIL Activity Sheets, Videos, and PowerPoint presentations were also utilized. A posttest was administered to the class after completing the topic. This was given to the student participants at the appropriate time after the experimental period.

Statistical Techniques

Quantitative data was analyzed using descriptive statistics such as frequency, mean, percentages, and standard deviation to determine the student's level of cognitive learning outcome in Earth Science. A paired t-test was used to determine the significant difference in the cognitive learning outcome of students exposed to an online process-oriented guided inquiry learning approach, comparing the pretest and posttest. The one-sample t-test compared the students' cognitive learning outcomes to the existing competency standard.

RESULTS AND DISCUSSION

Students' Cognitive Learning Outcomes in Pretest and Posttest

Table 1 presents the cognitive learning outcomes of students in Earth Science before exposure to online process-oriented guided inquiry learning approach. As shown in the table, no student got "outstanding" results; only 1 (1.96%) obtained "very satisfactory"; 5 (9.80%) had "satisfactory"; 8 (15.69%) was "fairly satisfactory"; 37 (72.55%) "did not meet the expectation." The overall mean percentage score of the group is 65.83%, which indicates "did not meet expectation" results on their cognitive learning outcomes concerning the pretest.

Table 1. Students' Cognitive Learning Outcomes in relation to Pretest

Grading Scale	N	%	Descriptive Rating
90-100	0	0.00	Outstanding (O)
85-89	1	1.96	Very Satisfactory (VS)
80-84	5	9.80	Satisfactory (S)
75-79	8	15.69	Fairly Satisfactory (FS)
74 below	37	72.55	Did Not Meet Expectation (DNME)
TOTAL	51	100.00	
Overall MPS	65.83 (DNME)		

The result can be attributed to students' limited prior knowledge of the lesson in Earth Science. Previous studies noted that prior knowledge and experience may substantially influence the student's thinking and construction

of new concepts. The fundamental knowledge and skills seemed not adequately developed to reinforce the cognitive learning outcomes. According to Hanson (2013), a knowledge transfer cannot be expected if students have no adequate initial learning level. Moreover, students cannot transfer what they do not know and understand (Dong et al., 2020). In addition, students cannot grasp because they lack a thorough understanding of the topic to make it meaningful. Hence, there is a need to master the material in order to develop understanding.

Similar research findings on the effects of POGIL on students' performance showed that the pretest scores were low, which relates to low self-directed learning readiness (Bug-os & Caro, 2019). Kaundjwa (2015) reported that students exposed to the POGIL environment had a low pretest score, which did not meet the expected learning outcomes. This was attributed to the students' limited understanding of the focused subject, which exhibited the least mastered science concepts and failed to comprehend the topics.

Table 2 presents the cognitive learning outcomes of Earth Science students exposed to an online process-oriented guided inquiry learning approach. As gleaned from the table, 6 (11.76%) achieved an "outstanding" result while 12 (25.53%) was "very satisfactory," 11 (21.57%) obtained "satisfactory"; 13 (25.49%) was "fairly satisfactory, and only 9 (17.65%) "did not meet expectation." The overall mean percentage score is 80.2% which indicates "satisfactory" on cognitive learning outcomes concerning posttest.

Table 2. Students' Cognitive Learning Outcomes in relation to Posttest

Grading Scale	N	%	Descriptive Rating
90-100	6	11.76	Outstanding (O)
85-89	12	23.53	Very Satisfactory (VS)
80-84	11	21.57	Satisfactory (S)
75-79	13	25.49	Fairly Satisfactory (FS)
74 below	9	17.65	Did Not Meet Expectation (DNME)
TOTAL	51	100.00	
Overall MPS	80.20 (S)		

These findings indicate an increase in the student's cognitive learning outcomes. This can be directly associated with the exposure to online POGIL as a teaching-learning approach to knowledge acquisition in Earth Science. According to Noopur and Siu-Kit (2021), students' online learning outcomes were high after implementing POGIL. When POGIL was used as a pedagogy in the online environment, this improved the students' learning experiences and commitment to the class individually or in groups and received an overall high learning outcome.

Sanggara et al. (2018) investigated the learners' problem-solving in an online science laboratory through POGIL and found enhanced student learning outcomes. In online POGIL classes, learning groups could utilize the dynamic

virtual world to construct knowledge, communicate, argue, and solve or answer specific Earth Science problems or situations, improving students' understanding. This contradicts the study of Vanags et al. (2013), which reported that students exposed to POGIL had a low posttest score.

Hudson (2019) found that students achieved a high learning outcome after exposure to the POGIL approach. Furthermore, students exposed to POGIL classes acquire critical and analytical thinking skills and cognitive learning strategies that are considered significant learning outcomes (Tran & Lamar, 2020). Integrating the learning cycle as a model in online POGIL engages students in collaborative interaction and promotes the construction of knowledge. Cognitive research emphasizes that the learning cycle promotes the way students learn best. Hence, students achieved satisfactory cognitive learning outcomes in Earth Science.

Comparison of Students' Cognitive Learning Outcomes

Table 3 compares students' cognitive learning outcomes when exposed to online POGIL about their pretest and posttest. The pretest scores had a mean of 65.83 (SD= 10.81), indicating that the scores of students are spread out based on the standard deviation, which can be attributed to the variability of students' prior knowledge about the topic. On the other hand, posttest scores had a mean of 80.20 (SD=8.53), and the standard deviation was low, which implies that students' scores were clustered closely to the mean. The t-value was -9.39, indicating that the pretest and posttest are different, with a p-value of 0.000 indicating significance at 0.05.

Table 3. Comparison of Students' Cognitive Learning Outcomes between Pretest and Posttest

Cognitive Learning Outcomes	Mean	N	Std. Deviation	t-value	Sig. (2-tailed)
Pretest	65.83	51	10.81	-9.39	.000
Posttest	80.20	51	8.53		

LEGEND: *Significant at p<0.05

Based on the findings, students' cognitive learning outcomes significantly differed before and after exposure to the online POGIL approach. It was found that students achieved significantly higher scores in the posttest than in the pretest. The findings conformed to the results of Purkayastha et al. (2019), which revealed a statistically significant difference in students' performance before and after the implementation of POGIL. The POGIL approach increased students' performance on examinations, improved critical thinking skills, and provided an interactive class environment (Uy & Azuelo, 2022; Soltis et al.,2020).

Lestari et al. (2018) explained that the guided inquiry model substantially impacted students' cognitive achievement on the concepts of Stoichiometry.

Research reports by Kisworo and Gusman (2019) on the POGIL approach showed a better understanding of the content knowledge in science. Students' cognitive learning outcomes and critical thinking skills are better when POGIL is employed as a teaching strategy. This is consistent with the findings of Vacek (2011), who concluded that there was a notable change in the student's performance after an investigation of the effectiveness of POGIL as a teaching approach for Physical Sciences. However, the current study contradicts Roller (2015), which revealed no significant difference in grade performance when POGIL was employed.

Significant findings were noted by Irwanto et al. (2016) that students had shown excellent performance in problem-solving during the course process, and various questions were raised at the end under the POGIL method. Another study found that student significantly increased their performance as exposed to the POGIL environment (Ucang & Tan, 2013). The same POGIL employment by Ratti and Power (2018) observed increased students' performance from 54% to 85% in the first semester. It is noteworthy that current research revealed that using online POGIL as an instructional approach effectively improved students' cognitive learning outcomes, which is evident in the significant increase in their posttest scores. These results reject the stated null hypothesis that no significant difference exists in students' cognitive learning outcomes concerning their pretest and posttest as exposed to an online process-oriented guided inquiry learning approach.

Comparison of Cognitive Learning Outcomes and Competency Standard

Table 4 compares students' cognitive learning outcomes to the existing competency standard. The pretest had a mean of 65.83 (SD=10.81), indicating that scores of students are spread out based on the standard deviation, which is due to the students' different levels of prior knowledge about the topic. The t-value of -6.05 and p-value of 0.000 at 0.05 level means the students' cognitive learning outcomes in the pretest were less than the given competency standard. Meanwhile, the posttest had a mean of 80.20 (SD=8.53), indicating that students' scores were clustered closely to the mean. The t-value of 4.35 and p-value of 0.000 at 0.05 level means students' cognitive learning outcomes in the posttest significantly differed from the existing competency standard. It can be gleaned that after exposure to the online POGIL approach, the class had higher cognitive learning outcomes than the existing standard.

The minimum competency standard for elementary and secondary students is 75. This aligns with the Department of Education's goal to continuously improve the quality of learning outcomes (DO No. 8, s. 2015). Competency standards determine the specification of performance, students' abilities, and skills expected to be demonstrated about content standards and learning outcomes. Grading standards elicit and reward desired competence from the students. Research literature reported that it is important to compare students' competence (Knight & Cooper, 2019). The relationships between grades to standard and teacher's grading practices suggest that grades would assess both cognitive and non-cognitive factors (Brookhart et al., 2016).

Table 4. Comparison of Students' Cognitive Learning Outcomes to the existing Competency Standard.

Cognitive Learning Outcomes	Standard Mean	Mean	Std. Deviation	t-value	Sig. (2-tailed)
Pretest	75	65.83	10.81	-6.05	.000
Posttest	75	80.20	8.53	4.35	.000

LEGEND: *Significant at p<0.05

The current results were significantly different based on comparing students' cognitive learning outcomes in the posttest and the given competency standard. Students' cognitive learning outcomes in the posttest were significantly higher than the set standard as exposed to the online POGIL approach. The underlying reasons for good learning outcomes in online POGIL classes were adequate knowledge acquisition by one or more group members and the active participation of all members. Active interactions with peers, interactions with instructors, and engagement are the factors that affect performance (Milalos & Borres, 2025; Uy et al., 2024; Alaslani & Alandejani, 2020). As exposed to the online POGIL approach, students mastered the necessary competency, which they demonstrated in satisfactory learning outcomes. With the current research findings, the null hypothesis was rejected, stating that there is no significant difference in students' cognitive learning outcomes and the existing competency standard.

CONCLUSIONS AND RECOMMENDATIONS

After exposure to the online process-oriented guided inquiry learning approach, the student's cognitive learning outcomes showed a remarkable increase from did not expect to satisfactory. A significant difference existed between students' pretest and posttest in Earth Science. Thus, students' cognitive learning outcomes significantly improved. Students' cognitive learning outcomes in the pretest were significantly lower than the set competency standard. However, students' cognitive learning outcomes in the posttest were significantly higher than the set standard.

School principals, educators, and future researchers may explore more teaching variables contributing to high cognitive learning outcomes with the online POGIL approach. Further assessment may be carried out by teachers and future researchers and find other variables, such as students' engagement in virtual laboratory environments, to measure cognitive learning strategies. Curriculum planners may extend online POGIL as an instructional approach to other disciplines and find out how it significantly affects the student's learning outcomes compared to any existing competency standard. For future educational research, several pedagogical approaches may be adopted to correlate with the POGIL approach affecting the teaching and learning process.

FURTHER STUDY

This study focused only on Grade 9 students from a science high school in Philippines, so the findings may not reflect what might happen in other schools, grade levels, or countries. The O-POGIL approach was also used over a fairly short period, which might not have been enough time to see its full impact on students' learning.

ACKNOWLEDGEMENT

Researchers express deep sense of thanks and sincere gratitude to the advisory committee for the valuable guidance and insights throughout this research endeavor. To the participants of the study for their active involvement during O-POGIL implementation. Finally, to the Department of Science and Technology (DOST), Science Education Institute STRAND program for the great scholarship grant.

REFERENCES

Aderibigbe, S.A. (2020). Online discussions as an intervention for strengthening students' engagement in general education. *J. Open Innov. Technol. Mark. Complex. 6*. 98. https:// doi:10.3390/joitmc6040098

Alaslani, K. & Alandejani, M. (2020). Identifying factors that influence students' performance through social networking sites: An exploratory case study. *Heliyon, 6.* https://doi.org/10.1016/j.heliyon.2020.e03686

Andarino, F.C. (2019). Predictors of College Students' Academic Performance in the University of Eastern Philippines" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-3 | Issue-4, pp.1759-1765. https://www.ijtsrd.com/papers/ijtsrd23526.pdf

Artuz, J.K. & Roble, D. (2021). Developing students' critical thinking skills in mathematics using online-process oriented guided inquiry learning (O-POGIL). *American Journal of Educational Research, 9, (7). 404-409. https://doi*.10.12691/education-9-7-2

Brookhart, S.M., Guskey, T.R., Bowers, A.J., McMillan, J.H., Smith, J.K., Smith, L. F., Stevens, M.T., & Welsh, M.E. (2016). A century of grading research: meaning and value in the most common educational measure. *Educational, School, and Counseling Psychology Faculty Publications*. 2. https://uknowledge.uky.edu/edp_facpub/2

Bug-os, M. & Caro, V. (2019). Academic performance and attitudes towards General Physics of GRADE 12 students in a process-oriented guided inquiry learning (POGIL). *Sci.Int.(Lahore),31*(1). 31-34.

Department of Education Order No. 8, s. 2015. Policy guidelines on classroom assessment for the K to 12 basic Education program. Meralco Avenue, Pasig City.

Dong, A., Jong, M. S. & King, R.B. (2020) How does prior knowledge influence learning engagement? The mediating roles of cognitive load and help-seeking. *Front. Psychol.* https://doi:10.3389/fpsyg.2020.591203

Hanson, D. (2013). Instructor's guide to process oriented guided inquiry learning. New York: Stony Brook.

Hu, H. & Kussmaul, C. (2021). Improving online collaborative learning with POGIL practices. *SIGCSE.* https://doi.org/10.1145/3408877.3439682

Hudson, Z.M. (2019). The impact of process oriented guided inquiry learning on student understanding in ninth grade Physical Science. Master Thesis. Montana State University.

Idul, J. & Caro, V. (2019). Process-oriented guided inquiry learning (POGIL) on students' science process skills and academic performance. https:// doi:10.13140/RG.2.2.18763.92965

Irwanto, Saputro, A. D., Rohaeti, E., & Prodjosantoso, A. K. (2018). Promoting critical thinking and problem-solving skills of preservice elementary teachers through process-oriented guided-inquiry learning (POGIL). *International Journal of Instruction*, 11(4), 777-794. https://doi.org/10.12973/iji.2018.11449a

Kaundjwa, A. (2015). Influence of process oriented guided inquiry learning (POGIL) on the science foundation of students' achievement in Stoichiometry problems at University of Nambia. Master Thesis. University of Nambia.

Kisworo, B. & Gusman, T. (2019). Process oriented guided inquiry learning to increase student's critical thinking ability on Chemistry learning at Islamic High School in Cirebon. *AIP Conf. Proc*. https://doi.org/10.1063/1.5139782.

Knight, M. & Cooper, R. (2019). Taking on a new grading system: the interconnected effects of standards-based grading on teaching, learning, assessment, and student behavior. *NASSP Bulletin 103*(1) 65–92. https://doi:10.1177/0192636519826709

Kussmaul, C. & Pirmann, T. (2021). Guided inquiry learning with technology: investigations to support social constructivism. *Proceedings of the 13th International Conference on Computer Supported Education*.*1*,483-490. https:// doi:10.5220/0010458104830490

Lestari, P., Wardani, S. & Susilogati, S. (2018). Influence of guided inquiry model on students cognitive learning outcome in Stoichiometry topic. *Journal of Innovative Science Education. 7 (2). 130-135.*

Milallos, J.R. & Borres, T.H. (2025). Students' Reading Speed, Comprehension and Level of Engagement Through Read-Pair-Share. *International Journal of All Research Writings*, 6(8), 72-79.

Myers, T., Blackman, A., Andersen, T., Hay, R., Lee, I. & Gray, H. (2014). Cultivating ICT students' interpersonal soft skills in online learning environments using traditional active learning techniques. *Journal of Learning Design 7*(3), 38-53. https://doi.org/10.5204/jld.v7i3.194

Noopur, J. & Siu-Kit, L. (2021). Effects of process-oriented guided inquiry learning on approaches to learning, long-term performance, and online learning outcomes, interactive learning environments. https://doi: 10.1080/10494820.2021.1919718

OECD (2023), PISA 2022 Results (Volume I). (2023). In *Programme for international student assessment/Internationale Schulleistungsstudie*. https://doi.org/10.1787/53f23881-en

Purayastha, S., Guntu, M., Ravindran, R., & Surapaneni, A. (2019). Learning gains of process oriented guided inquiry. *European Conference on e-Learning*. https://doi:10.34190/EEL.19.124

Ratti, A. & Power, M. (2018). POGIL and reflection: A perfect duo to increase students' performance in a general chemistry course for engineering careers. 2177-0506.

Reynders, G. & Ruder, S. (2020). Moving a large-lecture organic POGIL classroom to an online setting. *Journal of Chemical Education*. https:// doi: 10.1021/acs.jchemed.0c00615

Roller, M. (2015). Fundamental Nursing: Process Oriented guided-inquiry learning (POGIL) research. *Journal of Leadership and Instruction. 20-23.*

Rumain, B. & Geliebter, A. (2020). A process-oriented guided-inquiry learning (POGIL)-based curriculum for the experimental Psychology laboratory. *Psychology Learning & Teaching. 19*(2) 194–206. https://10.1177/1475725720905973

Sanggara, P., Doyan, A. & Verawati, N. (2018). The effect of process oriented guided inquiry learning model based on virtual laboratory toward problem solving abilities of physics student. *JPPIPA: 5 (1).* https:// doi:10.29303/jppipa. v5i1.154

Sen, S. & Yilmaz, A. (2015). The effects of process oriented guided inquiry learning environment on students' self-regulated learning skills. *Problems of Education in the 21st Century.66.* https:// doi:10.33225/pec/15.66.54

Shi, Y., McLeod, J. & Yang, H. (2019). College students' cognitive learning outcomes in flipped classroom instruction: a meta-analysis of the empirical literature. *Journals of Computer in Education.* https://doi.org/10.1007/s40692-019-00142-8

Soltis, R., Verlinden,N., Kruger, N., Carroll, A. & Trumbo,T. (2015). Process-oriented guided inquiry learning strategy enhances students' higher level thinking skills in a Pharmaceutical Sciences course. *American Journal of Pharmaceutical Education*.79 (1). *Learning and Individual Differences*. *23,* 172-178. http://dx.doi.org/10.1016/j.lindif.2012.07.021

Tran, C. & Lamar, M. (2020). Fostering small group discussion in an online instrumental analysis course using Google Docs. *J Forensic Sci Educ.*2(2).

Trevathan, J. & Myers, T. (2013). Towards online delivery of process-oriented guided inquiry learning techniques in information technology courses. *Journal of Learning Design. 6(*2). https://10.5204/jld.v6i2.122

Tria, J. Z. (2020). The COVID-19 Pandemic through the Lens of Education in the Philippines: The New Normal. International Journal of Pedagogical Development and Lifelong Learning, 1(1). https://doi.org/10.30935/ijpdll/8311

Ucang, J., & Tan, D. (2013). Students' belief and mathematics performance in a process-oriented guide inquiry learning (POGIL) environment. *Central Mindanao University Journal of Science*, 141–157.

Udu, D. & Uwaleke, C. (2020). Non-randomized trial of POGIL for improving undergraduates' academic achievement in Science Education. *Universal Journal of Educational Research.* 8(9). http:// doi:10.13189/ujer.2020.080927

Uy Jr, R. F., Milallos, J. R., & Uy, M. F. (2024) Flipped-Pair-Share: An integrated strategy in enhancing students' performance and academic self-concept in English. *International Journal of English and Education.* 13 (3), 19-31. ISSN: 2278-4012.

Uy, R. F., Jr, & Azuelo, A. G. (2022). Students' Academic Self-Concept in Earth Science Through Online Process Oriented Guided Inquiry Learning Approach. *International Journal of Applied Science and Research*, *06*(01), 73–79. https://doi.org/10.56293/ijasr.2022.5484

Uy, R.F., Jr. & Tan, D.A. (2025). Students' Performance and Cognitive Skills in Chemistry Through Case-Based Learning Approach. *IJORER: International Journal of Recent Educational Research. 06*(02), 278-293. https://doi.org/10.46245/ijorer.v6i2.802

Vacek, J. J. (2011). process oriented guided inquiry learning (POGIL), a teaching method from Physical Sciences, promotes deep student learning in aviation. 78–89. https://doi:10.22248/okstate.18.100424

Vanags, T., Pammer, K. & Brinker, J. (2013). Process oriented guided-inquiry learning improves long term retention of information. *Adv. Physiol Educ. 37.* 233-241. https://doi:10.1152/advan.00104.2012

Villagonzalo, E. C. (2014). Process oriented guided inquiry learning: An effective approach in enhancing students' academic performance. DLSU Research Congress ,2 (1) 1-6). https://semanticscholar.org/6df4/19f58f5c2189dc0fb6267f1fcbdb8dfd6a

Walker, L., & Warfa, A. (2017). Process oriented guided inquiry learning (POGIL) marginally effects student achievement measures but substantially increases the odds of passing a course. *PLoS ONE 12*(10): e0186203. https://doi.org/10.1371/journal.pone.0186203

Zgraggen, S. (2018). Comparing the process oriented guided inquiry learning (POGIL) method to an independently developed guided inquiry method (InDGIM) in a High School Academic Chemistry Course. *Graduate Theses & Dissertations*. 17. https://scholarworks.arcadia.edu/grad_etd/17