ACADEMIC PERFORMANCE AND ATTITUDES TOWARDS GENERAL PHYSICS OF GRADE 12 STUDENTS IN A PROCESS-ORIENTED GUIDED INQUIRY LEARNING (POGIL)

Mary Allein Antoenette C. Bug-os[1], Virgencita B. Caro[2]
[1]University of Science and Technology of Southern Philippines, Cagayan de Oro City, Philippines.
[2]Central Mindanao University, Musuan, Maramag, Bukidnon, Philippines
Correspondence: Tel. +63 917153 4347, E-mail: allein.bugos@ustp.edu.ph

ABSTRACT: *The effects of Process-Oriented Guided Inquiry Learning (POGIL) on students' performance and attitudes in Grade 12 was examined. A quasi-experimental research design was used in the classes; one in POGIL and the other in non-POGIL class. The instruments were composed of an academic assessment and an attitude survey. Descriptive statistics, t-test, and analysis of covariance (ANCOVA) were used. Results revealed a significant difference in the academic performance of students in a POGIL from those in the non-POGIL class. The attitudes of students in POGIL was significantly higher than those in the non-POGIL class.*

Keywords: POGIL, academic performance, general physics, attitude

1. INTRODUCTION

It is undeniable that physics as one of the natural science subjects has a great contribution in the technological advancement of the nation. However, based on the Commission on Higher Education statistics only few enrolled and graduated over the past years compared to other courses. In addition, it is evident from the results of National Achievement Test given to the basic education that learners performed low in science including physics[1]. It is well known that learners in both high school and college find physics difficult. These motivate educators to use variety of strategies to put student's performance in physics on a pedestal. Also, to address the demand to produce learners who knew not only how to write, read and do arithmetic but learners who are able to perform process skills.

One of these strategies is the process-oriented guided inquiry learning (POGIL) is an approach that shifts the focus in the classroom from the teacher to the student[2]. POGIL focuses on the students' development of content knowledge and process skills[2][3]. In a POGIL classroom, students work in small groups with different roles [4]. It allows the students work on specially designed activities that promote mastery of discipline content and the development of skills in the processes of learning, thinking, problem-solving, communication, teamwork, management, and assessment[5]. The students work in self-managed teams to analyze data and draw conclusions. The instructor serves as the facilitator rather than the primary source of information[6].

The POGIL activities follow a learning cycle. First, students explore a model or data to find trends or patterns and generate and test hypotheses to help understand or explain the data. Then, students define or invent a new concept using the trends or patterns. Lastly, students apply the new concept in other contexts to help generalize its meaning and applicability[7].

The groups are working on worksheets that allow students to formulate the concept on the basis of what the students learned from the data, diagrams and illustrations presented [2]. The key components of POGIL worksheet include a descriptive title, models which can be a data or figures for students' exploration, questions to promote concept development, exercises for practice, and problems to apply the concepts [8][9]. The sequence of key questions is used to guide the teams through inquiry process. Key questions include direct questions, convergent questions and divergent questions. The questions guide students through the learning cycle and help them develop process and learning skills[7]. POGIL allows students to use higher order thinking skills[6].

The use of POGIL was observed to enhance student engagement, knowledge retention, and higher-level thinking and application skills[10]. Students' examination scores showed an increased performance on questions requiring higher-order thinking, and students' skills in problem-solving and critical thinking [11, 12, 13]. There was a significant increase in the students' performance in POGIL instruction[14, 15]. POGIL is mostly used in chemistry courses and allied courses[7][10]. Its effect on general physics specifically in geometric optics was not get describe. Also, students' attitude plays a role in the physics courses[16] several researchers found that there was a significant positive correlation on the attitude and academic performance in physics [17][18] Thus, the study aims to determine the academic performance and attitude of students in a process-oriented guided inquiry learning in learning general physics.

2. METHODOLOGY

2.1 Research Design

The study was a quasi-experimental research design to determine the student's academic performance in General Physics II. A pretest-posttest method was used to determine the significant difference in the academic performance of the Grade 12 Senior High School students in a process-oriented guided inquiry learning. Two intact groups of students participated in the study.

2.2 The Instruments

A 50-item multiple-choice type of test was conducted by the researcher to measure the academic performance of the students. A Table of Specification (TOS) was prepared to check the content specified with levels of cognitive domains. The questionnaire was subjected to content validation by experts to determine whether the test items are appropriate to test students' knowledge and content mastery of the topic in Geometric Optics. The test also obtained a reliability coefficient of 0.77. These questions served as the pretest, posttest and retention test. The academic performance of the students exposed to process-oriented guided inquiry learning was interpreted following the scale for the interpretation of data.

Table 1. Mean Score and Qualitative Interpretation of the Data

Mean Percentage Score	Qualitative Interpretation
90-100	Outstanding
80-89	Very Satisfactory
70-79	Satisfactory
60-69	Fair
59-below	Did Not Meet Expectation

Another instrument used in this study was the adapted Colorado Learning Attitudes about Science Survey questionnaire on students' attitude towards learning physics consists of thirty (30) items which have been tested for both its validity and its reliability. This was administered to the participants of the study to determine their attitude towards learning physics. The five-point Likert scale was used to analyze the attitude of students towards learning of general physics.

2.3 The Participants

The participants of the study were the grade 12 senior high school students in Science, Technology, Engineering and Mathematics (STEM) strand. Both groups passed their General Physics I. The participants were chosen randomly.

2.4 Data-Gathering Procedure

Prior to instruction, the pretest was given to determine the initial level of the learning competencies of the students in General Physics II specifically in Geometric Optics. After the selected topics were covered, a post-test (same as the pretest) was given to determine the students' performance. An attitude test was also administered prior to and after the treatment to determine the attitude of the students in learning physics. A retention test was also administered weeks after of the last class session.

During the implementation of the strategy, students exposed to POGIL were assigned randomly to groups of four with assigned roles: manager, scribe, librarian, and spokesperson. Students were asked to sit with members of their group in all class meetings. Each class period consisted of a brief lecture on background material and POGIL activity POGIL exercises or activities involves learning cycle with three phases: exploration, concept invention, and application. The instructor acted as the facilitator during POGIL exercises. Facilitation focused on listening to student discussions and offering guidance without revealing answers to the exercises. After reporting, the facilitators identified the misconceptions the students had and made necessary corrections. On the other hand, the non-POGIL class was conducted following the traditional procedure of delivery, generally lecture then an assessment by paper and pencil test.

3. RESULTS & DISCUSSION

This section presents the analysis and interpretation of the data obtained from the study.

Table 2. Students' academic performance in non-process-oriented guided inquiry learning.

NON-POGIL							
	PRETEST		POSTTEST		RETENTION		
Mean Percentage Score	N	%	N	%	N	%	Qualitative Interpretation
90-100	0.0	0.0	0.0	0.0	0.0	0.0	Outstanding
80-89	0.0	0.0	5.0	13.9	3.0	8.3	Very Satisfactory
70-79	3.0	8.3	20.0	55.6	30.0	83.4	Satisfactory
60-69	33.0	91.7	11.0	30.5	3.0	8.3	Fair
59 and below	0.0	0.0	0.0	0.0	0.0	0.0	Did Not Meet Expectation
Total	36.0	100	36.0	100	36.0	100	
Overall MPS	**67.22**		**72.97**		**73.56**		

Table 2 presents the academic performance of the students exposed to non-process-oriented guided inquiry learning. The pretest score of the students shows that 91.7% belong to the range of 60-69 or "Fair" while 8.3% belong to the range of 70-79 or "Satisfactory". On the posttest, scores that belong to "Fair" and "Satisfactory" ranges had percentages of 30.5% and 55.6% respectively. The 13.9% of the scores belong to "Very Satisfactory" range. The same table presents the students' retention performance in non-POGIL class. The scores on the range of 60-69 or "Fair" was 8.3% and on the range of 70-79 or "Satisfactory" was 83.4%. The 8.3% of the scores belong to "Very Satisfactory" range. This means that students' performance in non-POGIL class had improved from pretest to retention test. Interestingly, the non-POGIL group had scores that reached the "Very Satisfactory" range despite the conventional way of instruction.

Table 3 presents the academic performance of the students exposed to process-oriented guided inquiry learning. The pretest score of the students shows that 92.9% belong to the range of 60-69 or "Fair" while 7.1% belong to the range of 70-79 or "Satisfactory".

Table 3. Students' academic performance in process-oriented guided inquiry learning.

POGIL							
	PRETEST		POSTTEST		RETENTION		
Mean Percentage Score	N	%	N	%	N	%	Qualitative Interpretation
90-100	0.0	0.0	0.0	0.0	0.0	0.0	Outstanding
80-89	0.0	0.0	10.0	23.8	11.0	26.2	Very Satisfactory
70-79	3.0	7.1	30.0	71.4	31.0	73.8	Satisfactory
60-69	39.0	92.9	2.0	4.8	0.0	0.0	Fair
59 and below	0.0	0.0	0.0	0.0	0.0	0.0	Did Not Meet Expectation
Total	42.	100	42.0	100	42.0	100	
Overall MPS	**66.86**		**75.17**		**75.95**		

Looking at the scores of the students, the two groups are comparable. The posttest scores of students show that 4.8% of them were still on the range of 60-69 or "Fair". Interestingly, 88.1% of the students had improved their scores. On the range of 70-79 or "Satisfactory" was 71.4% and on the range of 80-89 or "Very Satisfactory" was 23.8%. Students' retention performance show 73.8% of scores belong to the range 70-79 or "Satisfactory" and 26.2% belong to the range 80-89 or "Very Satisfactory". The result conformed to Simson and Shandle [10] who found that the use of POGIL promotes knowledge retention.

The POGIL group scores did not meet the range of "Outstanding". This could be associated with the new strategy employed in the classroom. The students in POGIL group were not used to the POGIL strategy in learning general physics. The noticeable increase in performance is relatively connected with the application phase of the POGIL activity wherein students apply their knowledge to a new context. As a group, the students are able to communicate, argue and compromise in solving or answering a certain physics problem.

The non-POGIL group obtained a mean percentage score of 67.22 in the pretest and 72.97 in the posttest. The POGIL class obtained a pretest mean percentage score of 66.86 and it increased to 75.17 in the posttest. Both groups showed an increase in their performance from the pretest to the posttest. The retention mean percentage scores of the non-POGIL and POGIL groups were 73.56 and 75.95 respectively. It only suggested that instruction, regardless of strategy, always bring in some learnings to the students. But the POGIL group mean score in the posttest was higher than the non-POGIL group. It is consistent that students experiencing POGIL instructions scored higher on the examinations than students in traditional classes[8, 19].

Table 4 shows the Analysis of Covariance (ANCOVA) for students' performance in the posttest with pretest as covariate between groups. The F-value is equal to 11.639 ($p < 0.05$) between groups indicating highly significant difference. There was a significant increase in students' performance based on the post test result.

Table 4. Comparison of students' academic posttest results.

Grouping	N	Mean	Standard Deviation
POGIL	42	28.67	5.21
Non-POGIL	36	24.92	7.33
Total	78	26.94	6.51

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Group	366.495	1	366.495	11.639	.001
Covariance (Pretest)	632.400	1	632.400	20.083	.000
Error	2361.683	75	31.489		
Total	59859.000	78			

Students exposed to POGIL performed much better (mean = 28.67) compared to the students in non-POGIL group (mean = 24.92). These indicate that the use of POGIL instruction was effective in affecting change in the students 'performance. These findings are consistent with Vacek [4] towards the effectiveness of POGIL teaching strategy used for Physical Sciences which concluded the change in the students 'performance. Another study also revealed that there was a significant increase in the students 'performance after POGIL instruction[14].

Table 8. Comparison of students' attitude results.

Grouping	N	Mean Difference in Gain Scores	Standard Deviation	t-value	Sig.
POGIL	42	0.3943	.28193	3.975	.000**
Non-POGIL	36	0.0744	.42365		

**Significant at 0.05 level

Table 8 presents the mean difference in gain scores in the attitude of students exposed to POGIL and those in non-POGIL in learning general physics. Data revealed a mean difference score of 0.3943 (SD = .28193) for POGIL group and 0.0744 (SD = .42365) for non-POGIL with a t-value of 3.975 which was found significant at 0.05 level. This indicates that there was a significant difference in the attitude of students in a POGIL and those in the non-POGIL class in learning general physics. Thus, rejecting the null hypothesis that there is no significant difference in the attitude of students towards learning general physics in a POGIL and in a non-POGIL class. The results on the attitude of POGIL students towards learning general physics confirmed with Chase, Pakhira and Stains [15] that there was significant difference on the attitude of the students between the POGIL and control groups, thus enhanced students' perseverance as well as their attitude towards learning and the learning environment. Students appeared to be satisfied, enjoyed and more interactive with the use of group works in POGIL[18][19].

4. CONCLUSION AND RECOMMENDATION

Process-oriented guided inquiry learning (POGIL) had a significant difference in the students' academic performance in general physics particularly in geometric optics. Teachers may design learning worksheets or activities and implement in a process-oriented guided inquiry learning in other physics topics. There was also a significant difference in the attitudes of students in the POGIL and those in the non-POGIL class. Students exposed to process-oriented guided inquiry learning (POGIL) foster more positive attitudes towards learning physics after intervention. Science educators are encouraged to emphasize the importance of learning attitudes of the students in the classroom settings. Hence, teachers may consider to do more research investigation in order to advance the scientific knowledge regarding attitudes and how it influences physics learning. Educators, administrators, and teachers may initiate to incorporate process-oriented guided inquiry learning strategy into the curriculum. This may enhance the content mastery and process skills of the students not only in science but in other related subjects.

5. LITERATURE CITED

[1] Pardo, C. G. (2017). Self-Reported Difficulties in Physics as Predictor of Students Achievement. *International Journal of Scientific & Engineering Research*, *8*(3), 1134–1138.

[2] Bunce, B. D. M., Vandenplas, J. R., Neiles, K. Y., & Flens, E. A. (2010). Development of a Valid and Reliable Student-Achievement and Process-Skills Instrument. *Journal of College Science Teaching*, *39*(5), 50–55.

[3] Hu, H. H., Kussmaul, C., Knaeble, B., Mayfield, C., & Yadav, A. (2016). Results from a Survey of Faculty Adoption of Process Oriented Guided Inquiry Learning (POGIL) in Computer Science. *Proceedings of the 2016 ACM Conference on Innovation and Technology in Computer Science Education - ITiCSE '16*, 186–191.

[4] Vacek, J. J. (2010). Process Oriented Guided Inquiry Learning (POGIL), A Teaching Method From Physical Sciences, Promotes Deep Student Learning In Aviation Joseph J. Vacek University of North Dakota, 78–89.

[5] Brown, S. D. (2010). A process-oriented guided inquiry approach to teaching medicinal chemistry. *American Journal of Pharmaceutical Education*, *74*(7), 1–6.

[6] Villagonzalo, E. C. (2014). Process oriented guided inquiry learning: An effective approach in enhancing students' academic performance. *The DLSU Research Congress* , (2009), 1–6.

[7] Kussmaul, C. (2012). Process Oriented Guided Inquiry Learning (POGIL) for Computer Science, (February 2012), 373–378.

[8] Hanson, D. M. (2015). Designing Process-Oriented

Guided-Inquiry Activities Designing Process-Oriented Guided-Inquiry Activities. *Www.Reserchgate.Net/Publication/238073200*, *1*(March).

[9] Geiger, M. P. (2010). Implementing POGIL in Allied Health Chemistry Courses : Insights from Process Education. *International Journal of Process Education*, *2*(1), 19–34.

[10] Simonson, S. R., & Shadle, S. E. (2013). Implementing Process Oriented Guided Inquiry Learning (POGIL) in Undergraduate Biomechanics : Lessons Learned by A Novice. *Journal of STEM Educ a Tion* , *14*(1), 56–64.

[11] Soltis, R., Verlinden, N., Kruger, N., Carroll, A., & Trumbo, T. (2015). Instructional Design and Assessment Process-Oriented Guided Inquiry Learning Strategy Enhances Students' Higher Level Thinking Skills in a Pharmaceutical Sciences Course, *79*(1), 1–8.

[12] Moog, R. S., Creegan, F. J., Hanson, D. M., Spencer, J. N., & Straumanis, A. R. (2006). Process-Oriented Guided Inquiry Learning: POGIL and the POGIL Project. *Metropolitan Universities*, *17*(4), 41–52.

[13] Barthlow, M. J., & Watson, S. B. (2014). The Effectiveness of Process-Oriented Guided Inquiry Learning to Reduce Alternative Conceptions in Secondary Chemistry. *School Science and Mathematics*, *114*(5), 246–255. https://doi.org/10.1111/ssm.12076

[14] Ucang, J., & Tan, D. (2013). Students' Belief and Mathematics Performance in a Process-Oriented Guide Inquiry Learning (POGIL) Environement. *Central Mindanao University Journal of Science*, 141–157.

[15] Chase, A., Pakhira, D., & Stains, M. (2013). Implementing process-oriented, guided-inquiry learning for the first time: Adaptations and short-term impacts on students' attitude and performance. *Journal of Chemical Education*, *90*(4), 409–416.

[16] Perkins, K. K., Adams, W. K., Pollock, S. J., Finkelstein, N. D., & Wieman, C. E. (2005). Correlating student beliefs with student learning using the Colorado learning attitudes about science survey. *AIP Conference Proceedings*, *790*, 61–64.

[17] Akpinar, E., Yildiz, E., Tatar, N., & Ergin, Ö. (2009). Students' attitudes toward science and technology: an investigation of gender, grade level, and academic achievement. *Procedia - Social and Behavioral Sciences*, *1*(1), 2804–2808.

[18] Stefan, M., & Ciomoş, F. (2010). The 8th and 9th Grades Students' Attitude Towards Teaching and Learning Physics. *Acta Didactica Napocensia*, *3*(3), 7–14.

[19] Myers, T. (2012). Overcoming the Glassy-Eyed Nod: an Application of Process-Oriented Guided Inquiry Learning Techniques in Information Technology. *Journal of Learning Design*, *5*(1), 12–22.