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Exploring Students' Academic Performance, Motivational Orientation and Self-Regulated Learning Strategies towards Chemistry

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Honelly Mae S. Cascolan[1*]

[1]College of Education, Pangasinan State University, Pangasinan, Philippines

Corresponding Email: hmcascolan.asingan@psu.edu.ph

Abstract

Chemistry is considered one of the most difficult subjects for college students. Process Oriented Guided Inquiry Learning activities are a student-centered teaching-learning strategy used in classrooms to improve students' academic performance. This study investigates the effectiveness of POGIL activities in teaching Chemistry in the two sections of Bachelor of Industrial Technology (BIT) students enrolled in Chemistry for the first semester of 2022-2023 to determine the academic performance, motivational orientation, and self-regulated learning strategies before and after the intervention. We administered the examination on Stoichiometry and Chemical Equations and Motivated Strategies for Learning Questionnaires before and after the intervention. BIT 1B had the POGIL activities for Stoichiometry, while BIT 1A had the traditional lecture on the same topic. For the second topic, chemical equation, the intervention was switched. BIT 1A had the POGIL activities, while BIT 1B had the traditional lecture. The result showed that most respondents were male since Industrial Technology is a male-dominated course. A significant difference was observed between the post-test scores of the students exposed to POGIL activities and traditional lectures. A significant difference was also observed in the motivational orientation and self-regulated learning strategies after exposure to POGIL activities. Students in a POGIL class perform better than students in a traditional class. It is recommended to use a student-centered teaching strategy such as POGIL, which encourages active learning in teaching Chemistry to improve students' academic performance.

Keywords: Academic performance, Motivational orientation, Self-regulated learning strategies, Chemistry, POGIL

INTRODUCTION

Chemistry is a central science that deals with the study of matter - its properties, composition, structure, and changes it undergoes. College Students considered Chemistry a difficult subject. Two of the topics considered difficult in general chemistry were stoichiometry and chemical reactions. Stoichiometry is from the Greek work stoicheion, which means "element" and metron, which means "measure" It includes the relationships between the quantities of the reactant and product in a chemical reaction. A chemical equation is the symbolic representation of a chemical reaction in the form of a chemical symbol and formula. It consists of the reactant and product in a chemical reaction.

Process-Oriented Guided Inquiry Learning (POGIL) is a student-centered strategy used in chemistry classrooms (Moog and Spencer, 2008). POGIL's helps students develop content knowledge and key process skills (Straumanis and Simons, 2008). In a POGIL classroom, the students work in learning teams in a guided inquiry activity to stimulate mastery of the content and develop skills in learning, communication, thinking, problem solving, assessment, management, and teamwork. In this learning environment, the student takes greater

responsibility for their learning by relying on their thinking skills rather than memorization. They also develop positive relationships with their classmates and teacher (Hanson, 2013).

Motivation is the willingness of a person to do something. Motivation enriches orientation so that the student is willing to master the task. Motivation is essential for academic achievement. Motivational orientation is the motivation of a student to act (Kirk, 2022). Academic motivation is important in determining student engagement in a class. Motivation influences learning (Edgar et al., 2019). The student's ability to self-concept is an important motivational predictor of the student's grade (Steinmayr et al., 2019).

Self-regulated learning is how students approach learning, work towards goals, and evaluate their performance. Students who practice self-regulated learning can find importance in their process of learning, improve academic performance, and continue to be effective once they enter the workforce (Linke et al., 2010). Students' self-generated feelings, actions, and thoughts that are oriented toward achieving goals are referred to as learning strategies. Implementing appropriate learning strategies is related to students' self-regulation behavior, which should be encouraged by pedagogical designs (Hasanbegovic, 2006).

Students' Academic performance in science is measured by the experience of the learners, its skill, and self-regulation as they engage their strategies in learning (Aquino and Bautista, 2022). Previous studies show that college chemistry students' success rate is low (Tabibzadeh, 2015). Students think that Chemistry is a difficult subject and have a negative attitude towards Chemistry (Cascolan, 2023; Sibomana et al., 2021). Students developed a problem with the mechanism to analyze chemical calculations (Graulich, 2015). Students also have difficulty relating chemistry concepts daily because they have difficulty understanding them (Hanson, 2017). Innovative teaching strategies such as cooperative learning and peer learning improve the academic achievement of students in chemistry (Amedu and Gudi, 2017). In an interactive-cooperative environment, students can communicate ideas to construct knowledge and solve problems (Zammi et al., 2021).

Hence, this study was conducted to explore the effectiveness of the POGIL strategy in teaching Chemistry, specifically on stoichiometry and chemical equations. It seeks to answer the following questions: 1. What is the profile of the students in terms of a. age, b. sex, c. average monthly family income. 2. What is the pretest score of students on stoichiometry and chemical equations? 3. What is the motivational orientation of students before POGIL activities? 4. What is the nature of students' self-regulated learning strategies before POGIL activities? 5. Is there a significant change in pretest and posttest scores of students on stoichiometry and chemical equations after POGIL activities? 6. Is there a significant difference

in the posttest scores of students in the POGIL class and traditional lecture? 7. Is there a significant difference in students' motivational orientation after POGIL activities? 8. Is there a significant difference in students' self-regulated learning strategies after POGIL activities??

METHOD

The research design used in this study was quasi-experimental. It involves choosing groups upon which pre-post intervention is tested without any random pre-selection process. A 50-item test on stoichiometry and a 50-item test on chemical equations was used to gather data on academic performance. Motivational Orientation and Self-regulated learning strategies were gathered using the Motivational Strategies for Learning Questionnaire (Duncan and Mckeachi, 2015). Pretest and posttest on stoichiometry and chemical equations were researcher-made tests.

Two classes of 1st year bachelor's in industrial technology (BIT) students enrolled in chemistry for the 1st Semester of 2022-2023 were the subject of the study. BIT 1B had the POGIL activities for stoichiometry, while BIT 1A had the traditional lecture. For the second topic, the chemical equations, BIT 1A had the POGIL activities, while BIT 1B had the traditional lecture. The two sections were switched so that the two sections will experience the POGIL activities.

In Chemistry class, POGIL activities were introduced in the topic of stoichiometry for BIT 1B and chemical equations for BIT 1A. POGIL activities help students develop understanding by employing the learning cycle in guided inquiry activities (Hanson, 2013). The teacher acts as a leader, a monitor/assessor, a facilitator, and an evaluator. As a leader, the teacher develops and explains the lesson and defines the objectives, criteria for success, and expected behaviors. As a monitor/assessor, the teacher oversees the class; they monitor and assess the whole class in the understanding, misconceptions, and difficulties in collaboration. As a facilitator, the educators intercede when fitting and inquires convenient critical-thinking questions to assist groups get it why they may be having trouble and to think about what they ought to do to progress and make advance. As an evaluator, the teachers give closure to the lesson by inquiring group individuals to report answers, summarize the major focuses, and clarify the team's work's techniques, activities, and comes about (Hanson and Moog, 2022).

Data were analyzed using descriptive and inferential statistics. Data gathered before the intervention were analyzed using mean and standard deviation. Comparison between the post-test scores of students in the two sections was analyzed using an independent sample t-test – Levenes' Test of Equality of Variances. Comparison between students' pretest and posttest scores was analyzed using a Paired-Sample t-test.

RESULTS AND DISCUSSION

Profile of the students

Around 103 students were the respondents of this study. As shown in Table 1 majority of the students (82%) had an age range from 18-19 years old, some of them had an age ranges from 20-21 years old (15%), and very few are in between 22-23 years old (3%). It can also be seen from the Table 1 that majority of the students are male (92%), and Bachelor of Industrial Technology is a male-dominated course. The table also shows that 84% of the students had an average monthly income below 10,000.00. Most of the students came from low-income families. As for their parents' occupations, 65% of the students' fathers were farmers, followed by drivers 17%. As per the mother's occupation, 56% of students' mothers were housewives, followed by helpers (22%) and vendors (17%). Their father's occupation was mostly farming, while their mother was mainly a housewife. Interviews with students revealed that before going to school and after school, they were helping their parents with household chores and on the farm. Some of them are working students to support their finances in their studies.

Table 1 Profile of the Students

Profile		BIT 1A (N=50)		BIT 1B (N=53)		Total (N=103)	
		f	Percent	f	Percent	f	Percent
Age	22-23	1	2	2	4	3	3
	20-21	5	10	10	19	15	15
	18-19	44	88	41	77	85	82
Sex	Male	49	98	46	87	95	92
	Female	1	2	7	13	8	8
Average Monthly Family Income	31,000-40,000	1	2	2	3	3	3
	21,000-30,000	2	4	3	6	5	5
	11,000–20,000	5	10	3	6	8	8
	10,000 below	42	84	45	85	87	84
Occupation of father	Teacher	3	6	2	4	5	5
	Construction Worker	3	6	2	4	5	5
	Driver	7	14	11	21	18	17
	Vendor	5	10	3	5	8	8
	Farmer	32	64	35	66	67	65

Profile		BIT 1A (N=50)		BIT 1B (N=53)		Total (N=103)	
		f	Percent	f	Percent	f	Percent
Occupation of mother	Teachers	2	4	2	4	4	4
	Vendor	8	16	10	19	18	17
	Helper	13	26	10	19	23	22
	Housewife	27	54	31	58	58	56

Academic Performance, Motivational Orientation and Self-regulated learning strategies prior to POGIL Activities

Before the intervention, a pretest on academic achievement, motivational orientation, and self-regulated learning strategies was administered to the two sections of Bachelor of Industrial Technology students enrolled in General Chemistry.

Academic Performance on stoichiometry and chemical equations prior to intervention

Table 2 revealed that the understanding of students on the topic of stoichiometry and chemical equations is weak. BIT 1A scored higher than BIT 1B in the pretest in both Chemistry topics – stoichiometry and chemical equations, but the scores were comparable. In a 50-item test on stoichiometry, BIT 1 A has a mean score of 18.73, while BIT 1B has a mean score of 18.24. For chemical equations, a 50-item test was also administered. BIT 1A has a mean score of 20.30, while BIT 1B has a mean score of 19.16. The table revealed that the students have a weak understanding of stoichiometry and chemical equations. They had difficulty understanding the mole concept. They were confused about the oxidation number. They also had difficulty balancing chemical equations, especially for a chemical formula with polyatomic ions.

Table 2 Pretest scores in Chemistry

Topics in Chemistry	Sections	Pretest Mean	Standard Deviation
Stoichiometry	BIT 1A	18.73	1.99
	BIT1B	18.24	1.45
Chemical Equations	BIT 1A	20.30	3.40
	BIT1B	19.16	3.07

Motivational Orientation and Self-regulated learning strategies prior to POGIL Activities

Motivational Orientation and Self-regulated learning strategies were determined using the Motivation and Learning Strategies Scales in the Motivated Strategies for Learning Questionnaire (MSLQ) (Duncan and Mckeachi, 2015). A 31-item motivational orientation and 50-item learning strategies scale were administered to the students. The questionnaire on the

motivation scale assesses the students' goals and value beliefs in a course, the student's beliefs about their skills to succeed in a course, and their anxiety in taking exams. The questionnaire on the learning strategies scale includes the use of different cognitive and metacognitive scales and the student management of different resources. A seven-point Likert scale from "not at all true to me" to "very true to me" was used by students to rate themselves (Duncan and Mckeachi, 2015).

Table 3 shows the motivational orientation before instruction. It can be glimpsed from the table that all the components of the motivational orientation were moderately high. Extrinsic goal orientation has the highest mean of 5.21. Students are very conscious of their grades; they participate in the task and activities to get high grades. Task value was the second highest, followed by test anxiety with a mean of 4.50 and 4.45, respectively. Students had a fear of failing if they took the exam. The result showed that students participate in class to get high grades but also fear failing the test. The lowest was self-efficacy, students are not confident in their performance in school.

Table 3 Students Motivational Orientation

Motivation	Mean	Standard Deviation	Interpretation
Intrinsic Goal Orientation	4.37	0.442	Moderately High
Extrinsic Goal Orientation	5.21	0.366	Moderately High
Task Value	4.50	0.418	Moderately High
Control of Learning Beliefs	4.09	0.445	Moderately High
Self-efficacy for Learning and Performance	3.48	0.371	Moderately Low
Test Anxiety	4.45	1.14	Moderately High

Legend: 1.00-1.75 Very Low, 1.76 – 3.50 Moderately Low, 3.51-5.25 Moderately High, 5.26 – 7.00 Very High

Table 4 revealed the self-regulated learning strategies of students. It can be seen from the table that very high students' self-regulated learning strategies were observed in rehearsal, time and study environment, and effort regulation with a mean of 5.49, 5.46, and 5.26, respectively, in a 7-point-Likert scale. Elaboration, Organization, critical thinking, peer learning, and help-seeking were rated moderately high. The lowest was metacognitive self-regulation, with a mean of 3.48. This includes planning, monitoring, and regulating. The result reflects a commitment to accomplishing their task even if there are difficulties because most students come from low-income families, and most do household chores and farm work while studying. Some are also working students. This also reflects that students manage their time in studying.

Table 4 Students' self-regulated learning strategies

SLR Strategies	Mean	Standard Deviation	Interpretation
Rehearsal	5.26	0.502	Very High
Elaboration	4.73	0.587	Moderately High
Organization	3.84	1.08	Moderately High
Critical Thinking	4.53	0.481	Moderately High
Metacognitive Self-regulation	3.48	0.632	Moderately Low
Time and study Environment	5.46	0.363	Very High
Effort Regulation	5.49	0.437	Very High
Peer Learning	4.48	0.571	Moderately High
Help Seeking	5.09	0.480	Moderately High

Legend: 1.00-1.75 Very Low, 1.76 – 3.50 Moderately Low, 3.51-5.25 Moderately High, 5.26 – 7.00 Very High

Academic Performance, Motivational Orientation and Self-regulated learning strategies after POGIL Activities

Academic Performance is a measurement of students' achievement in the academic subject. This study assesses the students' understanding of chemistry concepts, specifically stoichiometry and chemical equations.

Comparison of the pretest and post-test scores

Posttest was administered after every topic. BIT 1B had the POGIL activities in the first topic, stoichiometry, while BIT 1A had the traditional lecture. The second topic, balancing of chemical equations, was switched; BIT 1B had the traditional lecture while BIT 1A had the POGIL activities. Test on stoichiometry and chemical equations consists of 50 items each. The two sections were switched for the intervention so that the two groups would experience the POGIL activities.

Table 5 Paired Sample t-test on the pretest and posttest scores

Topics in Chemistry	Section	Posttest Mean	Pretest	Mean Difference	t-value
Stoichiometry	BIT 1A (Traditional)	40.03	18.73	21.30	30.793**
	BIT 1B (POGIL)	44.16	18.24	25.92	57.53**
Chemical Equations	BIT 1A (POGIL)	48.03	20.30	27.73	48.568**
	BIT 1B (Traditional)	46.31	19.16	27.15	39.414**

Note: BIT 1A=50, BIT 1B=53; * = p < .05, ** = p < .01

As revealed in Table 5, there is an increase in the posttest scores of the students in the POGIL class and traditional classes. For stoichiometry, a mean difference of 21.30 was observed for the traditional class, while 25.92 was seen for the POGIL class. For the topic of chemical equations, a mean difference of 27.73 was observed for the POGIL class, while a

mean difference of 27.15 was observed for the traditional class. Higher mean difference was observed for the POGIL class compared to the traditional class in both topics. A highly significant difference was observed between students' pretest and posttest scores in the POGIL class and in the traditional lecture. A POGIL class scored higher than students in the traditional lecture, with a mean score of 44.16 and 48.03 in stoichiometry and chemical equations, respectively. POGIL has a positive effect on student' conceptual understanding, students in a POGIL group gained more substantial improvement than in the control group because inquiry activities ensure the physical and mental participation of students in a learning process (Sen and Yilmas,2018). Students must actively learn to improve their mastery (Sari et al., 2023).

Table 6 Comparison of the posttest scores of the two sections enrolled in General Chemistry

Topics in Chemistry	Sections	Posttest mean	Standard Deviation	F-value
Stoichiometry	BIT 1A (Traditional)	40.03	3.65	5.263*
	BIT1B (POGIL)	44.16	2.44	
Chemical equations	BIT 1A (POGIL)	48.03	2.20	4.133*
	BIT1B (Traditional)	46.31	2.68	

Note: * = p < .05, ** = p < .01

Table 6 shows the post-test score of the students in the two topics in General Chemistry: stoichiometry and chemical equations. Levene's Test of Equality of Variances revealed a significant difference in the post-test score of students taught in a traditional lecture and using POGIL activities. Regarding stoichiometry, BIT 1B, the POGIL class, had a posttest mean score of 44.16, while BIT 1B, the traditional lecture, had a posttest mean score of 40.03 in a 50-item test. For the topic of chemical equations, the intervention was switched, BIT 1B, the traditional lecture, has a mean score of 46.31 while BIT 1A, the POGIL class, has a mean score of 48.03 in a 50-item test.

It can be seen from the table that the students in the POGIL class scored higher in achievement tests in Stoichiometry and Chemical Equations than the students in the traditional class. A significant difference was observed for the two topics at 0.05 significance level with the f-value of 5.263 and 4.133 for stoichiometry and chemical equations, respectively. Students learn more when in a team because they brainstorm their ideas for the correct answer. The result supports studies that POGIL material is an effective instructional strategy to help students conceptualize (Cascolan and Prudente, 2018). Students in a POGIL class had higher passing scores and performed 0.3 standard deviations higher on achievement tests than the students in standard lectures (Walker and Warfa, 2017). POGIL-based materials can assist students in learning. It could be used to enhance the students' learning (Cascolan,2020). POGIL pedagogy

effectively reduces students' alternate conception in chemistry rather than the traditional method (Barthlow and Watson, 2014). There was a significant increase in students' academic performance in POGIL from those in the non-POGIL class based on the post-test result (Bug-os and Caro, 2019). The academic performance in a POGIL class was satisfactory, while the non-POGIL course was fairly satisfactory. POGIL had a statistically significant effect on students' academic achievement; the average achievement result in a POGIL class is higher than in a control group (Walker and Warfa, 2017). POGIL is an important teaching-learning intervention to increase academic performance (Idul and Caro, 2022). Undergraduate students who learned by POGIL class had a better understanding of the content knowledge than the students who learned by lecture approach, as revealed by the higher score achievement test of students in the POGIL class (Udu, D.A., John, N.S., Uwaleke, C.C., Chukwunonso, O.B., Phina, A.A., and Attamah, C.A., 2020). Student learning using POGIL results in a greater grasp of content knowledge; students in a POGIL class has higher final exam score than in a traditional class (Hein, 2012). POGIL learning affects students' scientific literacy and critical thinking; POGIL learning performed better than students in expository learning (Aiman, U., Hasda, S., and Uslan, 2020). POGIL improves the examination score of students in Student Assessment of Growth and Excellence Chemistry (Mata, 2022). Process-Oriented Guided Inquiry Learning effectively improves students' academic performance in Chemistry. (Bodner,G., and Elmas,R., 2020).

Paired sample t-test on the differences in students' motivational orientation

Motivational orientation is the source of motivation to act. It originates from the internal desire for external compensation. It is characterized by intrinsic and extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, and test anxiety (Duncan and Mckeachi, 2015).

Table 7. Paired sample t-test of students' motivational orientation

Motivation	**Pretest Mean**	**Posttest Mean**	**Mean difference**	**t-value**
Intrinsic Goal Orientation	4.37	5.59	1.22	17.106**
Extrinsic Goal Orientation	5.21	5.29	0.08	1.373
Task Value	4.50	5.52	1.02	18.343**
Control of Learning Beliefs	4.09	4.98	0.89	15.212**
Self-efficacy for Learning and Performance	3.48	5.25	1.77	33.445**
Test Anxiety	4.45	3.99	-0.46	-3.310**

Note: N=103, df = 102, * = p < .05, ** = p < .05

Table 7 shows the paired sample t-test of the students' motivational orientation. A highly significant difference was observed in all the motivation sections except for extrinsic goal orientation because the pretest for extrinsic goal orientation is high. There is also an increase in the posttest score of students in extrinsic goal orientation; however, the increase in not significant because the pretest score of students in extrinsic goal orientation is already high. The highest posttest mean was observed in intrinsic goal orientation, followed by task value with a mean of 5.59 and 5.52, respectively. The highest increase was observed in self-efficacy for learning and performance, which was 1.77 followed by intrinsic goal orientation, which was 1.22. A decrease in students' test anxiety after the POGIL activities was observed, with a post-test mean of 3.99. Students became more confident in taking the test after the POGIL activity. Students developed intrinsic goal orientation and task value after the POGIL activities. It also lessens the anxiety of taking the test; students become more confident in taking the exam. Students also learn more by working collaboratively with their peers rather than individually. Students prefer learning material that challenges them so that they can learn new things. A big increase in the post-test score was observed in self-efficacy for learning and performance; students became confident that they understood the concept taught. Students are curious to learn new things. An intrinsic goal orientation towards academic tasks means that students participate in a task for challenge, curiosity, and mastery (Duncan and Mckeachi, 2015). Students are also interested to learn the content area of chemistry. A learner with a high level of intrinsic goal orientation is more likely to form a set of learning goals that, ultimately, how they process information (Lange and Kim, 2021). The POGIL model increases the learning motivation and mastery of the concept and can train the learner's analytical thinking.

Students will easily understand the concept if they are directly involved in learning (Aristiyarini, Rudibyani, and Sunyono, 2022). A decrease in test anxiety of students after the POGIL activities was observed with a posttest mean of 3.99. Students became more confident in taking the test after the POGIL activity. An important part of the teaching-learning process is motivation. Intrinsic motivation makes learners increase their perseverance in learning and develop mastery of the content (Karadan, M., and Hameed, A. 2016). POGIL improves the teaching of students, and it motivates them to participate actively in activities (Artuz and Roble, 2019). POGIL learning model increases students' motivation and improves academic achievement (Santoso et al., 2023). Self-efficacy is a significant predictor of student learning; students develop a positive view towards teamwork and thought through a problem (Yadav et al., 2021)

Paired sample t-test on the differences in students' self-regulated learning strategies

Self-regulated learning strategies give students more control over their learning. Students are encouraged to understand their motivation for learning. Self-regulated learning strategies include cognitive and metacognitive strategies such as rehearsal, elaboration, organization, critical thinking, and metacognitive self-regulation, and resource management strategies such as time and study environment, effort regulation, peer learning, and help-seeking (Duncan and Mckeachi, 2015).

Table 8 Paired sample t-test of student self-regulated learning strategies

SLR Strategies	Pretest Mean	Posttest Mean	Mean difference	t-value
Rehearsal	5.24	5.42	0.18	2.377*
Elaboration	4.70	5.58	0.88	14.895**
Organization	3.88	5.54	1.66	14.027**
Critical Thinking	4.56	5.98	1.42	20.594**
Metacognitive Self-regulation	3.48	5.63	2.15	26.115**
Time and study Environment	5.04	5.59	0.55	10.095**
Effort Regulation	5.47	5.69	0.22	2.579*
Peer Learning	4.46	6.34	1.88	20.848**
Help Seeking	5.09	5.87	0.78	9.685**

Note: N=103, df = 102, * = $p < .05$, ** = $p < .01$

Table 8 explicitly shows the paired sample t-test of the students in the self-regulated learning strategies. There is a significant difference in the pre and posttest of the students in all the areas of self-regulated learning strategies. A significant increase was observed in elaboration, organization, critical thinking, metacognitive self-regulation, time and study environment, peer learning, and help-seeking. There is a small increase in effort regulation, but it is still significant at 0.05. The highest posttest mean was observed in peer learning (6.34), followed by critical thinking (5.98) and help-seeking (5.87). Students learn more through collaboration. Cooperative learning and teamwork, manifested during the activity, played an important role in improving academic performance. Students also ask for assistance if they don't understand the lesson. Research has documented that students learn, understand, and remember more when working together. Students in a learning team have greater mastery and retention and use critical thinking and higher level of reasoning. Learning models of POGIL significantly affected students` critical thinking ability and cognitive improvement (Kisworo and Gusman, 2019). Help-seeker students outperform students who avoid seeking help, and encouraging self-regulated learning behaviors can benefit students academically (Rege, Havaldar, and Shaikh, 2016). POGIL improves students' learning and motivates them to actively participate in class

activities (Artus and Roble, 2021). Students have positive views about teamwork, developing skills to work with others, and thinking through problems (Aman et al., 2021). POGIL has a greater impact on students' self-regulated learning skills than traditional chemistry instruction (Sen, Yilmas, and Geban, 2015). Compared to traditional lectures, POGIL effectively supports student learning (Rodriguez et al., 2020).

CONCLUSION

The use of POGIL Activities improves the academic performance of Students. Students learn more as a group by brainstorming in answering guided inquiry activities. Motivation is important in academic achievement. Motivational orientation is the source of motivation to act. A highly significant difference was observed in the majority of the sections of motivation. Students are curious to learn new things. Having an intrinsic goal orientation towards academic task means that students participate in a task for challenge, curiosity and mastery. Students prefer learning material that challenges them so that they can learn new things. A big increase in the post-test score was observed in self-efficacy for learning and performance; students became confident that they understood the concept taught. Students are curious to learn new things. Students became more confident in taking the test after engaging in POGIL Activities.

Students who practice self-regulated learning can find importance in their own learning process, improve academic performance, and continue to be effective once they enter the workforce. Cooperative learning and teamwork, which were manifested during the activity, played an important role in improving academic performance.

SUGGESTIONS

Using POGIL activities in teaching Chemistry is recommended because students nowadays learn more in groups as they brainstorm in answering guided inquiry activities. Teaching must be restructured, supporting the use of student-centered strategies such as POGIL, which supports active learning strategies for the improvement of the academic performance of students in chemistry.

REFERENCES

Aiman, U., Hasda, S., and Uslan (2020). The Influence of Process Oriented Guided Inquiry Learning (POGIL) Model Assisted by Realia Media to Improve Scientific Literacy and Critical Thinking Skill of Primary School Students. European Journal of Educational Research, Vol.9, Issue 4. pp 1635-1647. [https://pdf.eu-jer.com/EU-JER_9_4_1635.pdf].

Aman, Y., Mayfield, C., Moudgalya, S.K., Kussmaul, C., and Hu, H.H. (2021) Collaborative Learning, Self-Efficacy, and Student Performance in CS1 POGIL. In Proceedings of the 52nd ACM Technical Symposium on Computer Science Education. pp.775-781. [https: //doi.org/10.1145/3408877.3432373].

Amedu, O. I., and Gudi, K. C. (2017). Attitude of Students towards Cooperative Learning in Some Selected Secondary Schools in Nasarawa State. Journal of Education and Practice, 8(10), 29–34.

Aquino,J.E. and Bautista, R.G. (2022). CHEMIKA and Students' Academic Achievement in Chemistry. American Journal of Educational Research, 2022, 10(8), 501-507. DOI:10.12691/education-10-8-4.

Aristiyarini,D., Rudibyani, R.B., and Sunyono, T.F. (2022). Effectiveness of the POGIL Model to increase learning motivation and mastery of the concept of buffer solutions students. Asian Journal of Educational Technology, Vol.1No.1, pp 15-21. [ttps://doi.org/10.53402/ajet.v1i1.12]

Artus, J.K.A. and Roble, D.B. (2021) Developing Students' Critical Thinking Skills in Mathematics Using Online-Process Oriented Guided Inquiry Learning, Americal Journal of Educational Research, 9(7), pp 404-409. [http://pubs.sciepub.com/education/9/7/2]

Barthlow, M.J. and Watson, S.B. (2014) The Effectiveness of Process-Oriented Guided Inquiry Learning to Reduce Alternative Conceptions in Secondary Chemistry. School Science and Mathematics, 15(5). pp. 246-255. [https://doi.org/10.1111/ssm.12076]

Bodner,G., and Elmas,R. (2020). The impact of inquiry-based, group-work approaches to instruction on both students and their peer leaders. European Journal of Science and Mathematics Education,8(1),pp.51-66.

Bug-os, M.A.A.C., and Caro, V.B. (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),pp 31-34.

Cascolan, H.M.S. (2023). The Effect of Flipped Classroom Environment on Academic Achievement, Self-efficacy and Metacognitive Awareness of Students towards Chemistry. In 2023 the 14th International Conference on E-Education, E-Business, E-Management and E-Learning (IC4E 2023), February 01–04, 2023, Shenzhen, China. ACM, New York, NY, USA. https://doi.org/10.1145/3588243.3588248

Cascolan, H.M.S. (2020). Design, Implementation and Evaluation of a module on Climate Change. Journal of Critical Reviews, Vol.7, 2449-2456. http://www.jcreview.com/admin/Uploads/Files/61c9b7b08f3639.36352712.pdf.

Cascolan, H.M.S.; Prudente, M.S. (2018). Using Process Oriented Guided Inquiry Learning in Teaching Climate Change. *Advanced Science Letters***,** 24; pp. 2761-2765. [https://doi.org/10.1166/asl.2018.12466]

Duncan, T., and Mckeachi,W.J. (2015). Motivated Strategies for Learning Questionnaire Manual. Research Gate.

Edgar, S., Carr, S.E., Connaughton,J., and Celenza,A. (2019). Student motivation to learn: is self-belief the key to transition and first year performance in an undergraduate health professions program?. BMC Medical Education. 19:111. https://doi.org/10.1186/s12909-019-1539-5.

Graulich, N. (2015). Research and Practice The tip of the iceberg in Organic Chemistry classes : how do students deal with the invisible ? Chemistry Education Research and Practice, 16, 9–21. https://doi.org/10.1039/C4RP00165F.

Hanson, D. (2013). Instructor's Guide to Process-Oriented Guided-Inquiry Learning. Illinois;Pacific Crest. Available online: https://pcrest.com/research/POGIL_Instructor_Guide2014.pdf (accessed on 20 September 2022)

Hanson, R. (2017). Enhancing teacher trainees ' understanding about Cchemical reactions and equations. International Journal of Academic Research and Reflection, 5(6), 57–68.

Hanson,D.M., and Moog, R.S. Introduction to POGIL. Available online: http://www.pcrest.com/PC/pub/POGIL.htm (accessed 20 September 2022).

Hasanbegovic, J. (2006). IGIP Course materials, Module 5 - Tutoring and Collaboration. Available online: https://edutechwiki.unige.ch/en/Learning_strategy#cite_note-1. (accessed on 23 December 2022).

Hein,S.M. (2012). Positive impacts using POGIL in organic chemistry. Journal of Chemical Education, 89(7):860-864.

Idul,J.J.A., and Caro V.B. (2022). Does process-oriented guided inquiry learning (POGIL) improves students' science academic performance and process skills. International Journal of Science Education, Vol. 44, Issue 12. https://doi.org/10.1080/09500693.2022.2108553.

Karadan, M., and Hameed, A. (2016). Exploring the Features of Metacognition and Achievement Goals in Process Oriented Guided Inquiry Learning Instruction (POGIL). International Journal of Education and Psychological Research, Vol.5. Issue 3.

Kirk, K. Develop Self-Regulated Learners: Using and Choosing the best strategies for the task. Available online: https://serc.carleton.edu/sage2yc/self_regulated/index.html (accessed on 22 December 2022)

Kisworo, B., and Gusman, T.A. (2019). Process oriented guided inquiry learning to increase student's critical thinking ability on chemistry learning at Islamic High School in Cirebon. AIP Conference Proceedings. [https://doi.org/10.1063/1.5139782]

Lange, C. and Kim, H.J. (2021). Relationships of Motivational Orientation and Creativity and Their Effects on Writing Performance. English Teaching, pp. 107-130. [https://doi.org/10.15858/engtea.76.2.202106.107]

Linke,J., Kirsch, P., King, A.V., Gass,A., Hennerici, M.G., Bongers, A., and Wessa, M. (2010). Motivational Orientation modulates the neutral response to reward. Neuroimage. [doi: 10.1016/j.neuroimage.2009.09.013. Epub 2009 Sep 19. PMID: 19770058]

Mata, L.E. (2022). The Effectiveness of POGIL on High School Student Chemistry End-of-Course Examinations. Science Education International 33(2), 171-180 https://doi.org/10.33828/sei.v33.i2.5

Moog, R.S. and Spencer, J.N. (2008) POGIL:An overview. *American Chemical Society, 1-13*. [https://pubs.acs.org/doi/pdf/10.1021/bk-2008-0994.ch001]

Rege, P., Havaldar, F., and Shaikh, G. (2016). An Effective Use of POGIL in Improving Academic Performance of Students and Their Approach in Organic Chemistry. International Journal of Science and Research Methodology, 4(1).

Rodriguez,J.G., Hunter,K.H., Scharlott, L.J., and Becker,N.M. (2020). A Review of Research on Process Oriented Guided Inquiry Learning: Implications for Research and Practice. Journal of Chemical Education,97(10), pp. 3506-3520.

Santoso,A., Sumari,S., and Setiadi, A.D. (2023). The effect of POGIL classroom on students' achievement and motivation on acid-base topics. AIP Conference Proceedings. https://doi.org/10.1063/5.0112292

Sari,Y. Qadar, R., and Hakim, A. (2023). Analysis of High School Students' Conceptual Understanding of Physics on Temperature and Heat Concepts. International Journal of STEM Education for Sustainability, Vol.3, No.1, pp. 212-224. DOI. 10.52889/ijses.v3i1.92.

Sen, S. and Yilmas, A. (2016). The effect of Process Oriented Guided Inquiry Learning (POGIL) on 11th Graders' conceptual understanding of electrochemistry. Asia-Pacific Forum on Science Learning and Teaching, Vol.17, Issue 2. [*https://www.researchgate.net/publication/314949073*]

Sen, S., Yilmas, A., Geban O. (2015). The Effect of Process Oriented Guided Inquiry Learning Environment on Students' Self-Regulated Learning Skills. Problems on Education in the 21st Century, Vol.66, pp.54-66. [DOI: 10.33225/pec/15.66.54]

Sibomana, A., Karegeya, C., and Sentongo, J. (2021). Factors Affecting Secondary School Students' Academic Achievements in Chemistry. International Journal of Learning, Teaching, and Educational Research. Vol.20, No.12, pp. 114-126.

Steinmayr,R., Weidinger A.F., Schwinger,M., and Spinath, B. (2019). The Importance of Students' Motivation for their Academic Achievement-Replicating and Extending previous Findings. Front Psychol.10:1730.

Straumanis, A., and Simons, E. (2008). A Multi-Institutional Assessment of the Use of POGIL in Organic Chemistry. *American Chemical Society*. 226-239. [10.1021/bk-2008-0994.ch019]

Zammi,M., Khoiriyyah,K., Wibowo,T., Lathifa,U., and Fibonacci,A. (2021). Developing POGIL-based worksheets of chemistry and unity of sciences. Journal of Physics: Conference Series, 1796, 012115. [doi:10.1088/1742-6596/1796/1/012115]