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Research Article

Cooperative Learning And Its Impact On Students' Achievement In Science

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ABSTRACT

This study investigated the impact of cooperative learning on students' achievement in science. Ninety students chosen through intact group sampling became part of this quasi-experiment using the pretest and post-test analysis. The study analyzed the data using the mean, standard deviations, and t-test. The results show that both the Control and Treatment groups achieved moderate levels in the pretest. In the post-test, both groups improved their performance, achieving an overall high score. However, their mean gain scores were below satisfactory, with the Control group achieving very low scores, while the Treatment group achieved lower scores. The variance in the pretest score between the two groups was not significant, although significant in the post-test. The mean gain score between the Control and Treatment groups was also significant. This result denotes the advantage of cooperative learning over the traditional lecture method in teaching science in high school. The study implies that cooperative learning significantly impacts students' learning experiences and improves their achievement in science.

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INTRODUCTION

The Philippines lagged in the Trends in International Mathematics and Science Study (TIMSS) assessments in 2019, scoring very low at 249 (IEA, 2019). According to the outcomes of the 2018 Program for International Student Assessment (PISA), the Philippines, alongside Panama, ranked as the lowest performers in the areas of mathematics and science (Source: OECD, 2018). These figures suggest the students' inadequate comprehension of scientific concepts and insufficient foundational knowledge of scientific facts (Baclig, 2020; Bernardo, 2020), with substantial implications for teacher accountability and reforms in the Department of Education's curriculum (Darling-Hammond, 2020; Smith & Benavot, 2019; Wiseman, 2012).

Studies investigating students' achievements in science are essential, especially since the human race faces the everyday challenges of climate change, pandemics, famine, and pollution. The world needs scientists to respond to these needs, which makes studies on students' achievement in science relevant and timely. The fight against these shared enemies starts inside the classroom by teaching students to cooperate and collaborate with peers to achieve a common goal (Cornell University, 2021). Imperatively, the science trend is no longer competition but cooperation among individuals and nations, given their global competencies (Center for Global Education, 2021).

There are several models of students' learning productivity. For example, Walberg's theory of educational productivity, which can apply to student's productivity in science, postulates that aptitude, environment, learning method, and teaching techniques influence educational achievements (Fraser, Walberg, Welch, & Hattie, 1987; Haertel, Walberg, & Weinstein, 1983; Reynolds & Walberg, 1992; Walberg, 1980; Walberg, Fraser, & Welch, 1986). Likewise, in the teaching and learning process, Walberg claimed that cooperative learning and effective classroom management could positively affect student achievement (Zins, Bloodworth, Weissberg, & Walberg, 2004).

Although cooperative learning has occupied many writeups in books and journals, it takes prudence to determine a subject's best teaching and learning approach (Godec, King, Archer, Dawson & Seakins, 2018). Significant discrepancies exist between theoretical teaching principles and their practical implementation in Philippine educational institutions. Those written in books and those practiced in the classroom sometimes differ, as implied by the TIMSS and PISA results (Greenway, Butt & Walthall, 2019; Irajpour, Safazadeh, Alimohammadi & Haghani, 2018). Even the National Achievement Test (NAT) results 2018 showed low students' achievement in science, revealing a gap somewhere.

Given this, the researcher conducted a study that tested the effectiveness of cooperative learning in science in the hope of helping solve the Problem of low achievement of students in the sciences while improving

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their social skills in the process. This study is unique because it utilized a quasi-experiment method with intact class samples. Significantly, this study would benefit the Department of Education as it proposed enhancements and changes in the science curriculum based on the findings.

This study looked into the impact of cooperative learning on students' achievement in science and proposed changes in the science curriculum based on the findings. Specifically, the following objectives guided the study, first is to describe the level of pretest mean scores of the Control and Treatment groups in the areas of Earth Science, Chemistry, and Physics; second is to ascertain the level of post-test mean scores of the Control and Treatment groups in the areas of Earth Science, Chemistry, and Physics; third is to assess the level of the mean gain scores of the Control and Treatment groups in the areas of Earth Science, Chemistry, and Physics; fourth is to determine the significance of the difference in the pretest mean scores between the Control and Treatment groups in the areas of Earth Science, Chemistry, and Physics; fifth is to determine the significance of the difference in the post-test mean scores between the Control and Treatment groups in the areas of Earth Science, Chemistry, and Physics; sixth is to determine the significance of the difference in the mean gain scores between the Control and Treatment groups; and lastly is to, propose enhancements to the Grade 12 science curriculum based on the study's results.

These were the study’s null hypotheses, tested at a 95 percent confidence level and a 5 percent error level: There is no significant difference in the pretest mean scores between the Control and Treatment groups in the areas of Earth Science, Chemistry, and Physics; There is no significant difference in the post-test mean scores between the Control and Treatment groups in the areas of Earth Science, Chemistry, and Physics; and there is no significant difference in the mean gain scores between the Control and Treatment groups.

The study focuses on the key elements of cooperative learning and teachers' role in developing students' thinking and learning when implementing this pedagogical practice in their classrooms.

METHODS

Research Respondents

The study's sample comprised entirely of Grade 12 students from the STEM strand at the University of Mindanao during the 2019-2020 academic year. The STEM strand had two classes in Grade 12; one of these classes was designated as the control group, while the other class served as the experimental group. This research, therefore, focused exclusively on these two classes in the STEM strand, excluding Grade 12

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students enrolled in other strands from the study. Thus, the study's scope remained focused on the impact of the cooperative learning intervention, specifically within the context of STEM education at the Grade 12 level.

This study used intact group designs, an entire class grouping. They are a type of quasi-experimental design commonly used in educational research. This design uses pre-existing groups (such as classes, grades, or schools) instead of randomly assigning individual participants to groups. This process is often done because of logistical constraints or ethical considerations that make random assignments impractical or impossible (Gall et al., 2007; Shadish et al., 2002).

While the sampling method employed an entire class grouping, it is essential to note that students maintained autonomy over their participation in the study. Regarding individual rights and research ethics, students' involvement was entirely voluntary. They had the freedom to opt into the study, and equally, they could withdraw their participation at any point during the study's duration, which spanned one grading period. This flexible approach ensured that any participant who chose to discontinue their involvement in the research would do so without incurring any penalty or charges, thereby preserving the ethical integrity of the study.

The researcher conducted this study at the University of Mindanao Senior High School Department, Bolton campus, Davao City, particularly the Science, Technology, Engineering, and Mathematics (STEM) strand. UM also offers the Humanities and Social Sciences (HUMMS) and Accountancy, Business, and Management (ABM) strands. Only the Grade 12 STEM students who were 18 years old were included in the study. Students that are not comfortable to participate can withdraw if needed.

Instrument and Materials

This study utilized a teacher-created test covering the subjects of Earth Science, Chemistry, and Physics. The test questionnaire was validated by a research panel comprised of science teachers, reinforcing its relevance and appropriateness for the research objectives. The researcher conducted a pilot test to ensure the test's consistency, validity, and reliability. He administered this preliminary test to 30 second-year college students, who had completed and passed their respective Earth Science, Chemistry, and Physics courses. Following the pilot test, data were analyzed using Cronbach's alpha, a commonly employed measure of internal consistency. The final questionnaire was meticulously curated to include only those items that achieved a Cronbach's alpha value of .70 or above, ensuring that each question contributed effectively to the overall reliability of the test. All items met this standard, with alpha values exceeding the .70 threshold. Further analysis and

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interpretation of the data followed based on the following scoring criteria: For a mean range of 21.00 – 25.00, its descriptive level is Very High, which means the respondents' performance in the pretest and post-test was outstanding; for a mean range of 16.00 – 20.00, its descriptive level is High, which means the respondents' performance in the pretest/post-test was very satisfactory; for a mean range of 11.00 – 15.00, its descriptive level is Moderate, which means the respondents' performance in the pretest and post-test was fair; for a mean range of 6.00 – 10.00, its descriptive level is Low, which means the respondents' performance in the pretest and post-test was poor; and for a mean range of 1.00 – 5.00, its descriptive level is Very Low, which means the respondents' performance in the pretest and post-test was very inferior.

Research Design and Procedure

In this research, the researcher utilized a quasi-experimental approach. Researchers often employ quasi-experimental research designs in social science, psychology, and education studies. This design mirrors an experimental study by including a comparison between groups. However, unlike an experimental design, a quasi-experimental approach does not involve randomly assigning participants to groups. Instead, researchers use existing groups such as classrooms, schools, or communities. The group selection makes the quasi-experimental design a preferred option for educational research, where random assignment may not be feasible or ethical, as Miller et al. 2020; Rogers & Revesz, 2020; and Thomas, 2020, have asserted. A quasi-experimental design can provide a way to make causal inferences or identify cause-and-effect relationships, but it does so with certain limitations compared to actual experimental methods. As explained in the previous paragraph, a quasi-experimental study does not randomly assign participants into groups, which means there may be systematic differences between the groups before the intervention is applied. These differences may confound, or mix up, the effect of the intervention with the impact of other variables. This effect is known as selection bias. So, to address these issues, researchers use various statistical techniques to control for these pre-existing differences. Still, there is always some uncertainty about whether all relevant factors have been accounted for (Murnane & Willett, 2010; Shadish et al., 2002).

The absence of a random assignment of subjects made this study quasi-experimental. Quasi-experiments use the non-random selection of participants in an experiment (Trochim, 2020), as used in this study: one group was the control, and the other was the experimental group. Although the non-random assignment was inferior to randomized assignments concerning internal validity, there were gripping motives for using quasi-experimental designs (Maciejewski, 2018), which used the pretest and post-test scores in this study.

In particular, this study utilized the Nonequivalent Groups Design (NEGD) since

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it assigned comparable science classes and gave a pretest and post-test on specific topics. Although similar, these groups were not equivalent. During the data analysis, if the group variance is significant, the inference is that the strategy applied is effective (Price, Jhangiani, Chiang, Leighton, & Cuttler, 2020; Reichardt, 2005; Thomas, 2020; Trochim, 2020).

In this context, the independent variable functioned as the cause and the dependent variable, the result, with the teaching-learning approach centering on cooperative learning. Moreover, this study evaluated the average improvement in scores from the pretest to the post-test for both the control and experimental groups to assess the potential impact of the implemented strategy.

The researcher strictly followed the University's established protocols for this study's data collection process. Initially, he secured an endorsement letter from the dean's office of the graduate school to confirm the research's purpose and authenticity. Accompanying this letter was a formal request, which the researcher sent to the principal of the University of Mindanao Senior High School. Following the principal's approval, the next stage involved circulating an Informed Consent Form (ICF) among the target participants for their signatures, signaling their voluntary participation. As the participants were all 18 years of age or older and the questionnaire focused solely on lesson content without requiring any personal information, there was no requirement for an additional assent form.

The researcher distributed the pretest questionnaires to the respondents in their classroom after obtaining the required signed ICFs. After completing the pretest, each participant reviewed their questionnaire. This process promoted transparency and gave them immediate feedback on their performance.

After giving the pretest, the researcher resumed regular instruction with two unique teaching strategies for the two classes. The experimental group, one class, experienced a teaching method focused on cooperative learning strategies, promoting active student collaboration and interaction. The other class, the control group, underwent traditional instruction, predominantly through lecture-style teaching.

This distinct instructional approach persisted throughout one grading period. At the period's end, the researcher gave a post-test to both groups. The teacher then analyzed and interpreted the meticulously collected data to measure the effects of the different teaching strategies.

The data collected in this study were analyzed using the following statistical tools: Mean measured the average level of both pretest and post-test scores. It provided a summary measure representing the typical scores in the pretest and post-test conditions. T-test has ascertained if a significant disparity existed between the average improvement in scores for the experimental and control groups. By

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comparing the two educational techniques, the analysis assisted in determining whether the cooperative learning strategy significantly impacted students' academic achievements in contrast to the conventional lecture-oriented method.

While conducting this study, the researcher diligently observed various ethical guidelines set by the University's research ethics committee with UMERC Protocol No. UMERC-2021-075. Participation in this study was entirely voluntary. The researcher clearly explained the study's purpose and anticipated roles, which allowed potential participants to make an informed decision about their involvement. There was no coercion or intimidation at any stage. Additionally, the researchers reassured participants that they could withdraw from the study without facing any consequences. Respecting the respondents' privacy was a critical ethical concern. To uphold this principle, the researchers collected no personal identifiers from the participants. They coded the questionnaires to ensure anonymity and presented all data in aggregated form, further enhancing the confidentiality of this study. The researchers prioritized gaining informed consent from the respondents and, thus, meticulously explained the Informed Consent Form (ICF), addressing any clarifications before the participants signed it. The researchers completed this process before administering the pretest and formally communicated their research intentions to the school principal and sought assistance in encouraging student participation, aiming for a high response rate to enhance the study's validity. The researcher designed the study to reduce the risk to participants as much as possible. By ensuring privacy and confidentiality, maintaining regular teaching and learning processes, and using non-sensitive test items, they created a relaxed and safe environment for student participation. The potential benefits of this study could be transformative, potentially revolutionizing science teaching methods. It could shift from traditional approaches to modern, engaging, potentially more effective strategies, such as technology-integrated cooperative learning. The researchers was aware of plagiarism's legal and ethical consequences and diligently acknowledged all sources through proper citation. In addition, they used Turnitin software to detect any unintentional similarity with existing works. The researchers maintained ethical practices by avoiding data fabrication, ensuring that the data used were exclusively collected via the study's designated instrument. They based all conclusions and recommendations directly on the study's findings. Maintaining the integrity of research data was a critical priority and, thus, strictly avoided manipulating materials, processes, or data, ensuring an accurate and genuine representation of the results. The study remained free from any influence by external funding sources that could potentially bias the results. Since it was self-financed and conducted fulfilling a graduate degree requirement, the researcher's judgment stayed impartial, based solely on the data collected and analyzed. This research was grounded in honesty at every stage, from participant recruitment to data analysis. Transparency about the study's purpose was

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a critical factor in maintaining the integrity of the research process. Before initiating data collection, the researchers sought approval from the school principal. Recognizing the collaborative effort in completing this study, the authorship comprises the researcher and the advisor, listed in that order. The adviser guided the researcher in all aspects of conducting the survey. Additionally, the researchers included their research information sheets in the final manuscript to provide comprehensive details about the authors.

RESULTS AND DISCUSSION

The section contains the results of the data analysis based on the study's objectives. The analysis points are the mean scores of control and treatment groups in earth science, chemistry, and physics. These are the objectives of the study: To describe the pretest and post-test mean scores of both groups, to assess their mean gain scores, to determine the significant difference in the pretest and post-test mean scores of both groups, and to determine the significant difference in the mean gain scores of both groups.

Pretest Mean Scores of Students' Achievement in Science

This study involved a total of 90 students. The sum of the pretest scores was divided by the number of students in the group to calculate the mean scores. Table 1 provides a detailed breakdown of the pretest mean scores for the Control and Treatment groups across Earth Science, Chemistry, and Physics subjects. The data revealed a moderate level of overall achievement in both groups. Specifically, the Control group achieved an overall mean score of 11.55 with a 2.05 standard deviation.

In contrast, the Treatment group's overall mean score was 11.57, with a slightly higher standard deviation of 2.44. These results reflect satisfactory performance in science subjects among the respondents. Furthermore, the relatively low standard deviations suggest that the scores were tightly clustered around the mean, indicating a consistent level of knowledge among the students.

The degree of deviation affirms no significant disparity in the students' understanding of these subjects.

Upon examining the detailed results, the data revealed that the Control group received average ratings in Chemistry (M=11.23; SD=2.51) and Earth Science (M=14.20; SD=2.89) but a lower rating in Physics (M=9.07; SD=2.59).

Meanwhile, the Treatment group's detailed results showed a moderate rating in Chemistry (M=14.26; SD=2.10) and lower ratings in Physics (M=9.49; SD=3.08) and Earth Science (M=10.93; SD=3.66). These

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outcomes suggest that the students may have lacked the necessary preparation in these subjects, hence the observed results.

Table 1
Level of Pretest Mean Scores of Students' Achievement in Science

	Subjects	Mean	SD	Descriptive Level
CONTROL GROUP	Chemistry	11.23	2.51	Moderate
	Physics	9.07	2.59	Low
	Earth Science	14.20	2.89	Moderate
	Overall Mean	11.55	2.05	Moderate
	Subjects	**Mean**	**SD**	**Descriptive Level**
TREATMENT GROUP	Chemistry	14.21	2.10	Moderate
	Physics	9.49	3.08	Low
	Earth Science	11.01	3.66	Moderate
	Overall Mean	11.57	2.44	Moderate

The pretest mean scores for both the Control and Treatment groups were *moderate*, suggesting that both groups had acceptable performance in Chemistry, Physics, and Earth Science. Generally, students have mediocre achievements in science subjects. The PISA results 2018 confirmed this, stating that the Philippines had the lowest math and science score, the same as Panama (OECD, 2018). Also, in 2019, the Philippines scored very low in science and math (IEA, 2019). With these results, one can surmise that students have difficulty in science and math in the Philippines and other countries. Baclig (2020) and Bernardo (2020) assumed that students have an insufficient foundational knowledge of scientific facts and an inadequate comprehension of scientific concepts. Thus, an unexceptional achievement in science subjects.

Many argued that students' lack of intrinsic motivation to study science subjects resulted in underachievement. However, the Programme for International Student Assessment (PISA) data proved otherwise. Countries with students' high motivation indices did not improve their science

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achievement. For instance, in Greece, Luxembourg, and Iceland, where student motivation was high, their achievement in science decreased (Karakolidis, Pitsia, & Emvalotis 2019). With the above results, researchers investigated what might have caused the low achievement. Acar (2019) found the following reasons: self-concept in science, knowledge of cognition, socio-economic status, the importance of science, gradual learning, and views on lab work gender.

One crucial research finding on this topic is the importance of pedagogy, curriculum, and social relationships. A pedagogy that promotes students' autonomy and self-determination is vital in raising students' engagement. Students who were given hands-on learning in science, like gardening, were more engaged in science activities and learning more (Williams, Brule, Kelley, & Skinner, 2018). This current study on cooperative learning is similar to the above analysis as it involved students' active participation in learning.

The teaching strategy is essential to students' achievement in any subject. For example, problem-based learning (PBL) is a strong pedagogy in Chemistry because it can improve students' achievement. A study in South Africa proved this. The research found that problem-based learning increased students' post-test scores significantly. Therefore, the study concluded that teaching strategy could greatly influence learning (Aidoo, Boateng, Kissi, & Ofori, 2016).

Parenthetically, there are different reasons for students' underachievement in science. Therefore, researchers have examined every facet of what might have caused it: socioeconomic standing, positioning of teachers, counselors, and parents (Pringle, Brkich, Adams, West-Olatunii, & Archer-Banks, 2012), spiritual intelligence (Saranya & Sangeetha 2017), gender (Acar, 2019), and motivation (Karakolidis, Pitsia, & Emvalotis, 2019; Williams, Brule, Kelley, & Skinner, 2018) among others. All these studies aimed to improve the performance of students in science.

Post-Test Mean Scores of Students' Achievement in Science

Table 2 discusses the post-test mean scores of both the Control and Treatment groups. Data showed that the Control group (CG) got a mean score of 16.40, with a standard deviation of 2.23, while the Treatment group (TG) got an 18.13 mean score with a standard deviation of 2.25. Both mean scores indicate high levels of achievement and that the students have increased their knowledge of the three science subjects. Looking back at the pretest, both groups have moderate ratings; in the post-test, they both have high ratings, suggesting that they have improved slightly from their pretest scores. The standard deviations of 2.23 (CG) and 2.52 (TG) indicate that the respondents have more or less the same answers in the post-test, which further hints that they were taught almost the same topics and learned at nearly the same pace.

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In examining the results in detail, the Control Group got average mean scores in Chemistry (M=15.25; SD=3.90) and Physics (M=15.80; SD=2.90) but a high mean score in Earth Science (M=18.16; SD=2.94). On the other hand, the Treatment group has all high mean scores in all three subjects: Chemistry (M=19.36; SD=1.96), Physics (M=17.49; SD=3.41), and Earth Science (M=17.53; SD=3.32). The individual mean scores suggest that the Treatment group performs better in Chemistry and Physics than the Control group.

The post-test mean scores of the Control and Treatment groups were *high*, meaning that students performed better in the post-test than in the pretest. In the pretest, their mean scores were both moderate. Students usually get lower scores in the pretest. Before starting the lesson, the teacher pretests the students to determine their baseline knowledge (Berry, 2008). The post-test is different. The teacher gives it after the instructions to measure the percentage of the ability gained (Kuehn, 2017).

Table 2

Level of Post-test Mean Scores of Students' Achievement in Science

	Subjects	Mean	SD	Descriptive Level
CONTROL GROUP	Chemistry	15.25	3.90	Moderate
	Physics	15.80	2.90	Moderate
	Earth Science	18.16	2.94	High
	Overall Mean	16.40	2.23	High
	Subjects	**Mean**	**SD**	**Descriptive Level**
TREATMENT GROUP	Chemistry	19.36	1.96	High
	Physics	17.49	3.41	High
	Earth Science	17.53	3.32	High
	Overall Mean	18.13	2.52	High

Moreover, administering a post-test has various objectives, such as examining a teaching strategy's effectiveness (Kuehn, 2017; Shivaraju, Manu, Vinaya, & Savkar, 2017). Moreover, post-tests provide summative data to both teachers and

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students. This summative data can be a basis for using a winning pedagogy in science subjects to ensure students' mastery of the subject matter (Malik & Chapman, 2017).

In this study, the purpose of the post-test was to determine the effectiveness of cooperative learning in teaching chemistry, physics, and earth science among junior high school students. The result was promising. Science teachers can use cooperative/collaborative learning in their classes. This learning pedagogy can increase students' motivation compared to traditional lecture methods (Tran, 2019). Furthermore, cooperative learning has a favorable learning effect as it supports permanent education, exposes students to team learning, and develops personal and social skills (Altun, 2015; Molla & Muche, 2018).

Mean Gain Scores

Table 3 presents the mean level gain scores. The SPSS syntax in computing the mean gain score is gain=post-test – pretest. Using that formula, the mean gain scores for this study showed that all mean gain scores are positive, meaning that the post-test scores are more significant than the pretest scores.

For the Control group, the highest mean gain score is for Physics (M=6.73; SD=2.83), followed by Chemistry (M=4.02; SD=3.37), then the least mean gain score is for Earth Science (M=3.96; SD=2.26). The overall mean gain score obtained by the Control group is deficient at 4.85, with a 3.10 standard deviation. Results indicate that students have advanced very little in these subjects, even with the lessons after the pretest.

As for the Treatment group, the group's overall mean gain score is low at 6.56, with a standard deviation of 2.76. The individual scores show that the Treatment group got a very low mean gain score in Chemistry (M=5.15; SD=2.08), moderate in Physics (M=8.00; SD=2.99), and low in Earth Science (M=6.52; SD=2.37).

Looking at Table 3, both groups have very low mean gain scores in Chemistry and moderate mean gain scores in Physics. These scores indicate that both groups have very little increase in their performance in the post-test. Although the treatment group got a higher mean gain score in Earth Science than the Control group; the difference is slight.

Mean gain scores result from deducting the pretest from the post-test scores. If the difference is positive, the post-test scores are more significant than the pretest scores (SAGE Publications, 2017). The mean gain scores in this study were all positive, indicating that the scores in the post-test were more remarkable than the pretest scores. However, although the post-test scores were high, they were still under the acceptable range. The Control group had a *very low* mean gain score, and the Treatment group had a *low* mean gain score.

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Table 3

Level of Mean Gain Scores of Students' Achievement in Science

	Subjects	Mean	SD	Descriptive Level
CONTROL GROUP	Chemistry	4.02	3.37	Very Low
	Physics	6.73	2.83	Moderate
	Earth Science	3.96	2.26	Very Low
Overall Mean Gain Score		**4.85**	**3.10**	**Very Low**
	Subjects	**Mean**	**SD**	**Descriptive Level**
TREATMENT GROUP	Chemistry	5.15	2.08	Very Low
	Physics	8.00	2.99	Moderate
	Earth Science	6.52	2.37	Low
Overall Mean Gain Score		**6.56**	**2.76**	**Low**

Parenthetically, what is crucial in the result of this study is that the post-test scores were positive in both groups, denoting a slight improvement in the post-test after applying the teaching strategy. However, in this instance, the mean gain scores are not conclusive as to whether the teaching and learning employed in both groups are effective. Hypothesis testing could answer this issue.

Significate Difference in the Pretest Mean Scores between the Control and Treatment Groups

Table 4 presents a significant difference between the pretest mean scores of the Control and Treatment groups. The table shows that the overall mean difference in the pretest mean scores between the two groups is insignificant because the alpha result is more prominent than 0.05, which is the significance level in this study. In determining the result's significance, the rule says that the p-value should be lower or equal to the set p-value. In this case, the result shows strong evidence against the null hypothesis; therefore, rejecting the null hypothesis and accepting the alternative hypothesis is imperative, owing to the less than 5% probability for the null hypothesis to be correct. On the other hand, the p-value bigger than the set p-value of 5% means that the test has no effect, thus, the probability that the null hypothesis is true.

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Table 4

Significant Difference in the Pretest Mean Scores between the Control and Treatment Groups

Subjects	Control		Treatment		t value	p-value	95% CI	
	Mean	SD	Mean	SD			Lower	Upper
Chemistry	11.23	2.51	14.21	2.10	-6.26	0.00*	-4.034	-2.09
Physics	9.07	2.59	9.49	3.08	-0.697	0.488	-1.621	0.78
Earth Science	14.20	2.89	11.01	3.66	4.674	0.00*	1.88	4.662
Overall	11.55	2.05	11.57	2.44	-0.147	0.883	-3.063	2.641

*significant at ∝ = 0.05

In this test statistic, the overall computed p-value=0.883 is greater than the set p-value of 0.05. Therefore, the result failed to reject the null hypothesis. The null hypothesis in this test says there is no significant difference in the pretest mean scores between the Control and Treatment groups. The alternative hypothesis states a significant difference in the average pretest scores between the two groups. Therefore, the p-value of 0.883, which accepted (failed to reject) the null hypothesis, denotes no significant difference in the pretest between the Control and Treatment groups. However, the reader must exercise caution in accepting that the result is absolute. What the test tries to prove is a significant difference. It does not convey that the difference between the two groups does not exist because the result is not significant. Instead, the result denotes that the difference cannot change the outcome significantly.

In the result per subject, only the pretest result in Physics (t-value= -0.697; p-value=0.488) is not significant, implying the absence of a significant difference in the pretest means scores between the two groups. The results of Chemistry (t-value= -6.26; p-value=0.00) and Earth Science (t-value= 4.674; p-value=0.00) are all significant. These p-values imply enough evidence to prove a significant difference in the pretest results between the two groups. The result indicates that the variances in the pretest mean scores were enough to move the result to a significant level. Therefore, the study accepted the alternative hypothesis, showing a substantial difference in the pretest mean scores.

The test statistic revealed a minor variance in both groups' pretest mean scores. Therefore, the result failed to reject the null hypothesis. The term "failed to reject the null hypothesis" is more appropriate to explain a statistical impact than "accepting the null hypothesis." This statement means that the test has not found a significant association between the two facts or that the test has no

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big data point to disprove the null hypothesis (Taylor, 2019). In this study, the variance in the pretest between the Control and Treatment groups was insignificant, which means there was not enough evidence to make the result meaningful. However, the result did not indicate any difference in the pretest mean scores. There was a difference in the variance, but not substantial considering that it was only two percent in favor of the Treatment group.

To discuss further, looking at the mean scores of the two groups, the Treatment group performed two percent better in the pretest than the Control group. Nevertheless, this slight difference did not provide conclusive evidence that the Treatment group was better than the Control group. The pretest determined the initial understanding of the groups about the topics (Knapp, 2016; Taylor, 2019).

Significant Difference in the Post-test Mean Scores between the Control and Treatment Groups

Table 5 presents the test statistic on the post-test mean scores between the Control and Treatment groups. The overall t-test result of -3.413 is significant at p<0.05. Other significant results are in Chemistry (t=-6.298; p=0.00) and Physics (t=-2.522; p=0.013) but not significant in Earth Science (t=0.94; p=0.35). The significant results convey that students performed better in the post-test. The table reveals that the Treatment group has higher mean scores than the Control group in chemistry and physics, implying that the cooperative approach used in the Treatment group is effective in teaching these science subjects. This result has implications for the teaching pedagogies employed by science teachers.

Unlike the test statistic result in the pretest, the post-test revealed a significant difference in the mean scores between the Control and Treatment groups. The post-test scores were positive, meaning they were higher than the pretest scores. In the post-test data, the mean score of the Treatment group was 169 percent more than the Control group. In other words, the significance of the variance lies with the Treatment group. The difference in the scores was substantial enough to move the result to a significant level (Kuehn, 2017; Shivaraju, Manu, Vinaya, & Savkar, 2017).

The result implies that the teaching and learning strategy applied to the Treatment group after the pretest was effective. Further, the result suggests that the cooperative learning method is a better pedagogy than the traditional lecture method. Some research proven cooperative learning is the best strategy for teaching science subjects (Altun, 2015; Molla & Muche, 2018; Tran, 2019). Thus, this study has some implications in the field of teaching.

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Table 5
Significant Difference in the Post-test Mean Scores between the Control and Treatment Groups

Subjects	Control		Treatment		t value	p value	95% CI	
	Mean	SD	Mean	SD			Lower	Upper
Chemistry	15.25	3.90	19.36	1.96	-6.298	0.00*	-5.401	-2.81
Physics	15.80	2.90	17.49	3.41	-2.522	0.013*	-3.028	-0.359
Earth Science	18.16	2.94	17.53	3.32	0.94	0.35	-0.697	1.948
Total	16.44	2.23	18.13	2.52	-3.413	0.001*	-8.186	-2.161

*significant at ∝ = 0.05

Significant Difference in the Mean Gain Scores between the Control and Treatment Groups

Table 6 presents the test statistic result on the mean gain scores between the Control and Treatment groups. Only Chemistry yielded a not significant t-test result (p=0.086), greater than 0.05, which implies that the two groups did not have substantial variance in their performance in the pretest and post-test. In other words, the test statistic failed to reject the null hypothesis, conveying that there is unlikely to be a significant difference in the variance of the pretest and post-test results.

On the other hand, Physics (t=-2.063; p=0.042) and Earth Science (t=-5.364; p=0.00) have significant t-test results, implying a substantial gain between the pretest and post-test mean scores. Furthermore, the data show that the Treatment group has more significant mean scores than the Control group; therefore, it is more likely that the significance lies in the Treatment group's scores. The result indicates that the cooperative learning strategy is better for teaching Physics and Earth Science.

Table 6. Significant Difference in the Mean Gain Scores between the Control and Treatment Groups

Subjects	Control		Treatment		t value	p-value	95% CI	
	Mean	SD	Mean	SD			Lower	Upper
Chemistry	4.02	3.37	5.15	2.08	-1.749	0.086	-2.23	0.143
Physics	6.73	2.83	8.00	2.99	-2.063	0.042*	-2.499	-0.046
Earth Science	3.96	2.26	6.52	2.37	-5.364	0.00*	-3.626	-1.665

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Total	4.85	3.10	6.56	2.76	-4.165	0.00*	-7.33	-2.594

*significant at ∝ = 0.05

The mean gain score derived from the post-test and pretest scores between the Control and Treatment groups was significant. The gains indicated the effectiveness of cooperative learning in teaching science subjects, especially physics and earth science. However, the increase in the mean score in chemistry was insignificant, inferring that cooperative learning was ineffective in teaching the chemistry subject.

Consequently, the mean gain scores are essential in determining the effectiveness of a particular process employed after the pretest. Researchers usually do this to establish the variance in the Control and Treatment groups' pretest and post-test scores. This design is vital since it allows the researcher to measure whether a procedure or method enhances performance contrasted to the previous state or condition (Frey, 2018; Smolkowski, 2019). With the proper teaching tools and item analysis, the students' learning competence in science can get better (Martinková, Hladká, & Potužníková, 2020).

CONCLUSION

Here are the suppositions of this study as it came to a close. The pretest scores revealed that the respondents were on an equal footing during the start of the study, as both groups got moderate pretest results. The post-test results showed that respondents also were on the same level of competence, considering that both got an overall high level of achievement. The results suggested that both groups performed at more or less the same level of astuteness even when exposed to different teaching and learning strategies. Additionally, in the mean gain scores, although the performance of both groups was below satisfactory, the Treatment group had a better performance than the control group.

Further, in the results, the test statistic showed an insignificant difference in the pretest mean scores of both groups because the result failed to reject the null hypothesis, suggesting that both groups have nearly the same performance. The impact was significant in the test statistic for the post-test, inferring that the performance between the Control and Treatment groups varied significantly, with the Treatment group having a star score in the post-test. Lastly, the mean gain scores revealed a significant difference, with the Treatment group gaining the advantage. The result denotes that cooperative learning is a better strategy for teaching science in high school.

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