The Effects of Online Collaborative Learning (OCL) on Student Achievement and Engagement

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Abstract

This study determined the effects of Online Collaborative Learning (OCL) on student achievement and engagement in physical science. A one-group pretest/posttest pre-experimental research design was employed. The participants were Grade 11 students (n=30) in a public stand-alone senior high school in Congressional District 1, Quezon City, Philippines, who were selected using purposive sampling. This study utilized five research instruments: (1) OCL-based lesson plans, (2) Learning Activity Sheets (LAS), (3) Physical Science Achievement Test (PSAT), (4) CIP Engagement Questionnaire, and (5) Student Learning Experience Survey. The collected data were analyzed and interpreted quantitatively and qualitatively. Quantitative data were obtained from the validated 40-item achievement test and the adopted engagement questionnaire, while responses to the Student Learning Experience Survey provided qualitative data. Paired t-test was employed to determine the significant difference in achievement and engagement before and after the OCL's implementation. The results showed a significant difference between the pretest and posttest mean scores of the students in the achievement and engagement in physical science. Likewise, there was a statistically significant difference between the pretest and posttest mean scores for all engagement factors: cooperation, interest, and participation. The result of the survey revealed that students' exposure to the OCL strategy was effective in facilitating significant improvements in their achievement and engagement in physical science. Overall, the findings signified that Online Collaborative Learning (OCL) as a teaching-learning strategy enhanced students' achievement and engagement in physical science.

Keywords: achievement, engagement, online collaborative learning, physical science

Looking closely at science learning, engaging all students to participate actively in science class activities has been one of the challenges that science teachers encounter most of the time. Students previously regarded to be more able by their peers frequently dominated the class, whereas students with poor academic track records chose not to participate (Lowry-Brock, 2016). According to research, academic achievement will improve if teachers can better engage their students (Hirtz, 2020). As to Carini et al. (2006), if students are actively involved in the classroom, they are more likely to show greater interest and participation in the lesson, thus leading to better performance. However, as schools transitioned to online learning in response to the COVID-19 pandemic, student engagement has been recognized as a challenge (Farooq et al., 2020; Nickerson & Shea, 2020; Perets et al., 2020). Similarly, according to Kukard (2020), maintaining a sense of collaboration and connection has been one of the most challenging components of teaching during a global pandemic.

Given the physical distance between online students, collaborative learning initiatives may help them connect and overcome feelings of isolation (Writers, 2018). According to Leow and Neo (2016), collaboration can strengthen student-to-student relationships that encourage engagement leading to increased achievement in the course. Additionally, collaboration contributes to topic understanding and interpersonal skills development that assist students outside the classroom (Falcione et al., 2019). However, a virtual-based collaboration differs from one held in a physical classroom in terms of interactions between group participants over geographic distances and from dispersed locations (Othman et al., 2013). Thus, online collaboration tools are often used to facilitate online collaborative learning (Writers, 2018).

Collaborative learning can take on many forms in the traditional classroom setting. Common examples include jigsaw activities, problem-based learning, peer review, and think-pair-share (Nokes-Malach et al., 2015). All these strategies can be used in online learning using an online collaboration tool (Writers, 2018). For instance, the digital version of Think-Pair-Share (TPS) allows students to collaborate in the same way that the traditional Think-Pair-Share activity does, but at a distance, using simple online tools like Google Docs. According to Othman et al. (2013), The "Think-Pair-Share" method is a low-risk, quick collaborative learning strategy that works well in a virtual environment. Students could benefit from the Google Docs TPS adaptation by focusing on teacher-led questions in one area and collaborating with others to better understand the concept (Slone & Mitchell, 2014).

Online collaboration tools like Google Docs promote engagement and student-centered learning, which is critical for developing communication and inquiry skills (Schneckenberg, 2014). Students can accomplish assignments while collaborating with peers to agree on assigned tasks. Teachers can provide immediate feedback to students, observe, motivate, and facilitate their work while they collect information for an assignment. By utilizing the cloud approach in teaching and learning, students and teachers can work on the same document simultaneously, offering more information, making corrections, and providing comments (Faulkner, 2019). Teachers that used 21st-century collaborative technologies like Google Docs discovered that students were more enthusiastic and motivated to learn and agreed that talking with their peers helped them better understand the learning content (Lin et al., 2016).

Online Collaborative Learning (OCL) is a widely used distance learning and teaching approach comparable to face-to-face collaborative learning; however, meetings in a group are held asynchronously or synchronously over the internet (Magen-Nagar & Shonfeld, 2017). Despite development in distance learning research, there is still no consensus on the effective utilization of ICT technologies in online teaching with virtual groups to produce interactive, collaborative learning that fosters effective learning (Ng, 2017). Moreover, it has not made much headway in the Philippines. There are also few to no empirical studies on the use of OCL in teaching physical science, and little is known about its application. This prompted the researcher to investigate whether OCL can improve students' achievement and engagement in the online classroom. Hence, this study determined the effects of Online Collaborative Learning (OCL) on student achievement and engagement in learning physical science. This study also utilized Google Docs as a collaborative learning tool to create and format text documents in real-time. Furthermore, the think-pair-share technique was adopted to facilitate online group activities, as it is short and ideal for use in a virtual learning environment (Othman et al., 2013). The following research questions guided the present study:

1. What is the student's achievement in physical science before and after their exposure to Online Collaborative Learning (OCL) strategy?
2. Is there a difference between the pretest and posttest mean scores of the students in the physical science achievement test before and after their exposure to the Online Collaborative Learning (OCL) strategy?
3. What is the student's engagement in physical science before and after their exposure to the Online Collaborative Learning (OCL) strategy in terms of:
4. cooperation
5. interest
6. participation
7. Is there a difference between the pretest and posttest mean scores of the students in the Cooperation, Interest, Participation (CIP) Engagement Questionnaire before and after their exposure to the Online Collaborative Learning (OCL) strategy?
8. What are the students' learning experiences of the Online Collaborative Learning (OCL) strategy?

Literature Review

Online Collaborative Learning (OCL) Strategy

Online Collaborative Learning (OCL) stems from social constructivism, in which students are encouraged to work collaboratively to solve problems through discussions. In OCL, the teacher is a facilitator and part of the learning community (Harasim, 2012). In distance learning, OCL is a widely used teaching approach based on the conventional collaborative learning method. The goal is to utilize technology to enhance communication between teachers and learners, focusing on the knowledge-based learning development supported and developed through social discourse (Bates, 2015). According to Koh and Hill (2009), online collaboration entails students working together to finish a task using electronic modes of communication regardless of time or geographic isolation. However, as Bates (2019) pointed out, the teacher's role in facilitating and providing resources and learner activities to ensure the integration of the core concepts, practices, standards, and principles remains critical to the success of online collaborative learning.

As for the effects of Online Collaborative Learning (OCL), Al-Ammary (2013) found that OCL has a significant impact on student achievement. However, OCL may influence student contributions because some students may rely on others to complete their work and may have a lower level of commitment to the group, which may impede communication among group members. Additionally, Ajayi and Ajayi (2020) used an online collaborative learning strategy with a quasi-experimental research design, notably the pre-and post-test control. The findings indicate that online collaborative learning techniques in Science Education improved undergraduate learning outcomes and retention. Furthermore, according to Nguyen (2015), there is strong evidence that online learning is as successful as traditional learning. In fact, according to Bernard et al. (2014); Means et al. (2010), some studies have shown that online learning has been reported to be more effective. Lastly, Tsai and Guo (2012) on the impact of Online Collaborative Learning (OCL) on student achievement. Results have shown that OCL had a favorable impact on student achievement, with various criteria emerging as predictors of student achievement.

However, some studies found that collaboration in virtual teams can be more challenging than in a conventional one. For example, during the COVID-19 pandemic, Mustakim and Adha (2021) discovered that, despite the teacher's ability to use online learning applications effectively, they still had difficulty fostering collaborative learning due to the presence of students in different locations, making coordination challenging. Andres and Shipps (2010) discovered that technology-mediated collaboration had more instances of communication failures and misunderstandings. A similar study by Koh and Hill (2009) found that online group activities were more difficult for students than working in face-to-face groups. The most challenging factors identified by students were communication issues and a lack of a sense of community.

Meanwhile, recent studies have shown that students enjoy and are engaged in collaborative learning when it is done digitally with innovative learning technology (Gopinathan et al., 2022). Baanqud et al. (2020) found that during the COVID-19 pandemic, digital collaboration is essential for student engagement to help them perform better in and out of the classroom. Even though students are participating remotely in the teaching and learning process, digital collaboration ensures that everyone gets the chance to share information and retain it. It was also found in other research by Chiero et al. (2015) and Fedynich et al. (2015) that online interaction between teachers and students improves learning outcomes and student satisfaction, which leads to better student engagement. Additionally, students' ability to communicate with their peers contributed to their enjoyment of learning (Lee et al., 2018), and the student's enjoyment of sharing ideas and working with others fostered cooperation (Lamina, 2020).

Google Docs Think-Pair-Share

Lyman introduced the Think-Pair-Share (TPS) structure in 1981, a collaborative learning structure in which students first think individually before forming ideas about the questions, then pair up with other students to discuss their answers. Finally, after the pair discussions, students share their responses with the entire class (Lightner & Tomaswick, 2017). This form of classroom activity encourages students to interact with one another and the lecturer, resulting in an active learning environment. It also encourages everyone in the class to participate, even those who are more reserved and less likely to speak up in class unless prodded. Studies using this structure have reported increased student engagement and enhanced learning outcomes (Razak, 2016; Raba, 2017). The digital version of Think-Pair-Share (TPS) offers new affordances, allowing students to work collaboratively but at a distance. Students engage well with the idea of messaging each other and creating some excitement around the task. Google Docs, a simple online tool, may provide a platform for the Think-Pair-Share (TPS) activities. When students use Google Docs to facilitate a TPS activity, they are encouraged to investigate a teacher-prompted question, collaborate with peers, write their answers to an electronic document, and finally project their collective results to the larger group (Slone & Mitchell, 2014).

Methodology

Research Design

This study employed a one-group pretest/posttest pre-experimental design, using quantitative and qualitative methods to analyze the data collected to address the research questions. The effect of the Online Collaborative Learning (OCL) strategy on student achievement and engagement was determined using quantitative analysis. The participants' learning experiences with OCL were analyzed qualitatively using thematic analysis.

Participants of the Study

The participants involved grade 11 (n = 30) senior high school students from one physical science class at a public stand-alone senior high school in Congressional District 1, Quezon City, Philippines. Purposive sampling was applied to select 30 students (4 males and 26 females) from the 42 students enrolled in the class. The inclusion criteria were: (1) Students who took the Online Distance Learning or ODL (the teacher facilitates the learning and engages the learners' active participation using technology via the internet during instruction). (2) With sufficient experience in online distance (ODL) learning (for one semester) during the pandemic outbreak. Students with above-average levels were paired up with below-average levels. Those having the same average level were paired together based on the Stanine scores taken from their first-semester final grade in the Earth & Life Science subject, forming a total of 15 pairs. This study did not include the twelve (12) students who took the Modular Distance Learning or MDL (learners who used self-learning modules or SLMs in digital/electronic copy).

Research Instruments

OCL-based Lesson Plans

The OCL-based lesson plans were adapted from the Teaching Guide (TG) for Senior High School in physical science. All the lesson plans aim to provide a general outline of the teaching goals on how students should learn, how it will be delivered, and measured, following the policy guidelines on daily lesson preparation for the K-12 Basic Education Program based on the principle of sound instructional planning. The researcher incorporated the Google Docs Think-Pair-Share activities on the lesson plans. All the lesson plans used in this study went through the phases of validation by experts and the research adviser using the Lesson Plan Evaluation Matrix before the implementation. Then, the researcher incorporated the comments and suggestions in refining the lesson plans.

Learning Activity Sheets (Google Docs Think-Pair-Share Activities)

The Learning Activity Sheet (LAS) is a self-directed instructional material that guides learners in completing activities at their own pace and time using contextualized community resources. Four collaborative Learning Activity Sheets (Google Docs Think-Pair-Share Activities) were developed on the topics: Polarity of Molecules, Intermolecular Forces, and Biological Macromolecules, with contents validated by the experts, peers, and the research adviser. The Learning Activity Sheets (LAS) were validated alongside the lesson plans, as these activities are incorporated into the lesson proper. The validators were given copies of the lesson plans with the learning activity sheets to provide feedback and suggestions for improving and refining the questions. Accordingly, changes were made based on the feedback and suggestions.

Physical Science Achievement Test (PSAT)

The Physical Science Achievement Test (PSAT) was constructed to measure students' level of understanding related to the topics: Polarity of molecules, Intermolecular Forces, and Biological Macromolecules, with sample questions in Appendix A. It measures three cognitive learning domains: remembering, understanding, and applying. The research adviser and the three science education experts evaluated the test's content and face validity using the validation tool adopted from the study of Lamina (2020). Then, it was pilot tested on 40 senior high school students who were not participants in the study and subjected to item analysis. From the initial pool of 60- multiple choice test items, only 40 good items were included in the final form using the index difficulty of 0.25 to 0.75 and the discrimination index of 0.3 and above as the acceptable item. The reliability coefficient is 0.83, which indicates that the test was highly reliable and appropriate for administration as a pretest and posttest of the study.

Cooperation-Interest-Participation (CIP) Engagement Questionnaire

The CIP Engagement questionnaire (in appendix B), adopted from the study of Lamina (2020), is a four-point scale self-assessment tool that measures the cooperation, interest, and participation (CIP) factors of engagement. This questionnaire contains 15 questions given as follows: the cooperation factor has four (4) questions (item nos.1-4), the interest factor has nine (9) questions (nos. 5-13), and the participation factor has two (2) questions (item nos. 14-15). The students have four responses to rate their engagement ranging from Strongly Agree (4), Agree (3), Disagree (2), and Strongly Disagree (1). The minimum score in the instrument is 15, and the maximum is 60.

Student Learning Experience Survey

The Student Learning Experience Survey contains three open-ended questions prepared by the researcher and validated by the same science expert-validators. The survey questions sought students' accounts of their experiences with OCL. The student responses to the three open-ended questions were thematically analyzed using the framework developed by Braun and Clarke (2006). This approach was chosen because it is useful for summarizing key features and generating unexpected insights (Braun & Clarke, 2006). The themes, sub-themes, and codes of the open-ended questions were derived from the answers that have the same concepts and ideas (Braun & Clarke, 2012). The researcher manually performed the data collection and coding procedure to identify similarities and differences in the participants' responses. The researcher applied the six-step process by Braun and Clarke (2006) to identify common ideas that came up repeatedly. The process involved (1) Familiarization, (2) Coding, (3) Generating Themes, (4) Reviewing Themes, (5) Naming Themes, and (6) Writing Up.

Data Gathering Procedures

Before the implementation of the study, the researcher obtained permission from the school head where the study was conducted. After the list of participants had been finalized, the researcher gave the Informed Consent letter to the selected participants. After this, an orientation session on online collaborative learning was carried out using Google Docs to introduce and familiarize students with the platform and its tools. The students were then paired up based on their computed Stanine scores. After grouping, the teacher discussed how the activity would run. The data-gathering procedure went through three different phases described below:

Phase I- Pretesting. Before the first lesson of the study, the teacher-researcher delivered a trial lesson about Exploring the Formation of Elements During Stellar Formation and Evolution, and the students completed an OCL activity using Google Docs Think-Pair-Share. The purpose of this trial lesson was to control the novelty effect. The pretest and the CIP Engagement Questionnaire were administered following the trial lesson to determine the pretest scores in the Physical Science Achievement Test and the CIP Engagement Questionnaire. The pretest lasted 60 minutes in the first session and 30 minutes in the second session for the CIP Engagement questionnaire.

Phase II- This phase involved the implementation of Online Collaborative Learning (OCL) using the Google Docs Think-Pair-Share Strategy. Physical science is generally taught four times per week in senior high, with two 1-hour synchronous class sessions and two 1-hour asynchronous sessions conducted each week based on the approved teacher's schedule.

Session 1 (Synchronous). The teacher-researcher discussed the topic for the week, guided by the OCL-based Lesson Plan for 60 minutes.

Session 2 (Asynchronous). The Learning Activity Sheet (Google Docs Think-Pair-Share Activity), created and saved in Google Drive by the teacher-researcher, was given to each pair via Google Classroom. A question was posed in the Learning Activity Sheet, requiring students to think individually about the question and record their answers/ideas in the activity sheet. In pairs, students discussed and compared their answers to the given question. While both students worked in Google Documents, they could view information simultaneously while chatting – allowing them to collaborate remotely.

Session 3 (Synchronous). Students shared their work with the whole class via Padlet, an online virtual board that supports collaborative learning in classroom teaching. Padlet is a free multimedia wall that encourages whole-class involvement by allowing real-time interaction among students and between students and the teacher (Fuchs, 2014). Four minutes were allotted for each pair to share and discuss their output with the whole class.

Session 4. (Asynchronous). Students were given a short evaluation via Google Forms to assess their understanding of the lesson.

Phase III- Post-testing and Learning Experience Survey. This phase involved administering the posttest using the PSAT and the CIP Engagement Questionnaire. The posttest lasted 60 minutes, while the CIP Engagement questionnaire took 30 minutes to complete. Then, the students responded to the Student Learning Experience Survey in the next session.

The study lasted six (6) weeks without interruption. All the gathered data were subjected to statistical treatment and analysis to determine the effect of the Online Collaborative Learning (OCL) strategy on students' achievement and engagement.

Data Analysis

The raw data were statistically processed and analyzed using the Excel "Data Analysis" tool. The mean and standard deviation were used to describe the students' achievement and engagement. The paired t-test was applied to determine the significant difference in the pretest and posttest mean scores in the achievement test and the CIP engagement in physical science before and after their exposure to the Online Collaborative Learning (OCL) Strategy at a 0.05 level of significance. Moreover, students' responses to the Learning Experience Survey were analyzed thematically using the framework developed by Braun and Clarke (2006).

Results

Student Achievement in Physical Science Before and After Their Exposure to Online Collaborative Learning (OCL) Strategy

The pretest and posttest were administered to determine student achievement before and after exposure to OCL. Table 1 shows the summary of the descriptive statistics based on the results of the pretest and posttest given to the students, which corresponds to the first research question.

Table 1
Descriptive Statistics of the Pretest and Posttest Scores of the Students in the Physical Science Achievement Test (n = 30)

Test	Highest Score	Lowest Score	Mean	Mean Difference	SD
Posttest	40	18	31.00	13.83	6.54
Pretest	27	6	17.17		5.32

Table 1 shows that the posttest has a mean score of 31.00, while the pretest has a mean score of 17.17, with a mean difference of 13.83. The result indicates that the student's scores in the achievement test improved after exposure to the OCL strategy suggesting that OCL is effective in enhancing student achievement.

Test of Significant Difference Between Students' Pretest and Posttest Mean Scores in the Physical Science Achievement Test (PSAT)

A paired t-test was applied to determine whether there was a significant difference between the pretest and posttest mean scores in the PSAT. Table 2 shows the paired t-test result, which corresponds to the second research question.

Table 2
Paired t-Test Between Students' Pretest and Posttest Mean Scores in the Physical Science Achievement Test (n =30)

Test	Mean	Standard Deviation	df	*t*-value	*p*-value	Remark
Posttest	31.00	6.54	29	9.89	<.001	Significant
Pretest	17.17	5.32				

Table 2 shows that the computed *p*-value is less than the 0.05 level of significance. Therefore, there is a significant difference between the student's pretest and posttest mean scores before and after exposure to the OCL strategy. The result suggests that students' achievement in physical science significantly improved with OCL.

Student Engagement in Physical Science Before and After Their Exposure to Online Collaborative Learning (OCL) Strategy

To determine the students' engagement in learning Physical Science before and after exposure to the OCL strategy, Cooperation-Interest- Participation (CIP) Engagement Questionnaire was administered among students. The engagement score of students in the pre and post-test in each factor was individually analyzed, which corresponds to the third research question.

Table 3
The Pretest and Posttest Mean Score in the Cooperation Factor of Student Engagement

Test	Mean Score	Mean Difference	Standard Deviation
Posttest	14.47	2.00	1.87
Pretest	12.47		1.43

Table 3 shows an increase in the students' mean score in the cooperation factor of engagement after exposure to the OCL strategy. This suggests that OCL is effective in encouraging student cooperation.

Table 4
The Pretest and Posttest Mean Score in the Interest Factor of Student Engagement

Test	Mean Score	Mean Difference	Standard Deviation
Posttest	33.37	3.84	3.51
Pretest	29.53		2.64

Table 4 shows an increase in the students' mean score in the interest factor of engagement after exposure to the OCL strategy. The result implies that OCL is effective in increasing student interest.

Table 5
The Pretest and Posttest Mean Score in the Participation Factor of Student Engagement

Test	Mean Score	Mean Difference	Standard Deviation
Posttest	6.90	0.97	1.09
Pretest	5.93		1.05

Table 5 also shows an improvement in the students' mean score in the participation factor of engagement after exposure to the OCL strategy. This result also indicates that OCL is effective in encouraging student participation.

Table 6
Students' Overall Mean Scores in the Cooperation, Interest, and Participation (CIP) Factors of Student Engagement (n = 30)

Test	Mean Score	Mean Difference	Standard Deviation
Posttest	54.73	6.8	5.64
Pretest	47.93		4.22

Table 6 shows an increase in the overall engagement mean score. This result indicates that OCL enhanced students' engagement in terms of cooperation, interest, and participation.

Test of Significant Difference Between the Pretest and Posttest Mean Scores of the Students in the Cooperation, Interest, and Participation (CIP) Factors of Engagement

The mean score of each factor in the engagement pretest and posttest were analyzed using paired t-tests to determine the significant difference between test scores, which corresponds to the fourth research question.

Table 7
Paired t-Test Between the Pretest and Posttest Scores of the Students in the Cooperation, Interest, and Participation (CIP) Engagement Questionnaire (n = 30)

Engagement Factor	Posttest Mean Score	Pretest Mean Score	*df*	*t*- value	*p*-value	Remark
Cooperation	14.47	12.47	29	5.34	<.001	Significant
Interest	33.37	29.53	29	4.94	<.001	Significant
Participation	6.90	5.93	29	3.59	.001	Significant
Overall	54.73	47.93	29	5.59	<.001	Significant

Table 7 shows that the overall computed *p*-value is less than the 0.05 level of significance. Therefore, there is a significant difference between the student's pretest and posttest mean scores in the three factors of engagement (cooperation, interest, and participation) before and after exposure to the OCL strategy. These findings indicate that OCL has a significant effect on improving students' engagement in physical science.

Students' Responses to the Learning Experience Survey

Analysis of the response data identified four major themes: (a) improvement in students' achievement, (b) facilitating students' engagement, (c) challenges encountered during the OCL implementation, and (d) convenience in the usage of the collaborative tool (Google Docs). Each is described below with illustrative student responses.

Improvement in Students' Achievement

The Student Learning Experience Survey results confirmed further that the OCL strategy improved student achievement. From the survey, three subthemes emerged across the student-participant responses: develop understanding, build knowledge, and knowledge retention. Understanding the lesson was by far the most frequently reported response from students. Fifty percent of the class stated that their partners provided additional explanations and assistance. Thus, they understand the lessons easily. A student-participant stated that OCL activities helped him understand the lessons much better. "*I understand the lesson clearly because my partner explains it further.*" He explained. Another student-participant said, "*Working with a partner helps because you have different points of view that can help you better understand the topic, and having different ideas made us more critical.*" Furthermore, two students expressed that having pair discussions naturally helps them retain information. "*I remember almost all the lessons taught because of this activity.*" *A* student-participant stated. Another student reported that his achievement improved with OCL because Google Docs think-pair-share activities allowed him to deepen his understanding and knowledge of the topics by exchanging ideas with others. Another shared that her scores improved as her partner pointed out her mistakes and guided her through the process. Another noteworthy finding was that students indicated that OCL helps them learn more as they work in pairs. A participant elaborated on this: "*I was able to understand complex topics through his explanations,*" referring to his partner.

Facilitating Students' Engagement

In terms of engagement, the common subthemes evident in the student-participant responses were cooperation, interest, and participation. Interestingly, most participants preferred working in pairs over individual activities, as their partners provided additional explanations. A student-participant commented, "*I got more interested and motivated to do our task as I got ideas from my partner.*" While another said, "*This method taught me to be more confident in sharing my ideas*." "*It was fun; we got to talk to our friends instead of listening to the teacher all the time,*" a student-participant added. The interest factor of engagement appears to be the most frequent response, followed by cooperation and participation. Overall, the findings indicate that OCL using the Google Docs Think-Pair-Share technique is a viable method for assisting students in becoming more involved and engaged in learning.

Challenges Encountered During the OCL Implementation

One of the primary issues that students encountered during the OCL implementation was poor internet connectivity. This problem resulted in lagging and spending more time than expected in sending answers. A participant noted, "*Working simultaneously with a partner was difficult due to an unstable internet connection.*" Time management was also a problem, as some students took a long time to respond to their partners. While most students enjoyed the Google Docs Think-Pair-Share activities, others lacked the confidence to share their opinions with the entire class. One participant stated, "*I'm a bit shy and intimidated as my partner dominates our conversation.*" Shyness, intimidation, and fear of embarrassment from giving incorrect responses shown by the students remain a concern that must consider when teaching.

Convenience in the Usage of the Collaborative Tool (Google Docs)

Apart from the challenges the students encountered during the OCL implementation, another theme that emerged was convenience, defined as the quality of being easy, useful, or suitable to proceed with something without difficulty (Oxford Dictionary). The analysis specifically identified Google Docs as a collaborative tool that was convenient for everyone, easy to access, and used. A student pointed out, "*It was convenient and easy to access compared to other apps*." "*It was very nice; no need to use Facebook messenger to chat,*" she said. They also found it interesting as they could see each other's answers while working on the document, allowing them to catch any issues upfront. A student elaborated on this: "*It was very nice; we were able to discuss when there is a problem or issues right away.*"

Discussion

The mean difference between the pretest and posttest scores confirmed that student achievement improved significantly at the end of the study. This result could be attributed to the OCL Google Docs Think-Pair-Share activities that allow students to craft and share ideas that address the guiding questions posed in the activities. Likewise, this finding could be also linked to the students' collaboration that contributes to topic understanding (Falcione et al., 2019) and student-student interactions that encourages engagement leading to increased achievement (Leow & Neo, 2016). Further, the paired t-test result revealed a significant difference between the pretest and posttest mean scores in the PSAT. This suggests that the OCL strategy, in which students learn collaboratively and in pairs, has a significant effect on their achievement in Physical Science. This conforms with the findings of Al-Ammary (2013), Ajayi et al. (2020), and Tsai and Guo (2012) that Online Collaborative Learning has a significant influence and positive impact on student achievement and learning outcomes. Moreover, this finding is also consistent with those of Othman et al. (2013), that a well-known "Think-Pair-Share" collaborative learning technique, which has been modelled in OCL, significantly provides a positive impact on student performance.

In the present study, students performed Online Collaborative Learning (OCL) using Google Docs Think-Pair-Share activities, which fosters social skills and develops cooperation when students brainstorm in pairs while each learns from their partners. Thus, the improvement in the cooperation factor of engagement in Table 3 could be associated with the Google Docs Think-Pair-Share activities in the OCL approach. This result conforms to the study of Lamina (2020) that the enjoyment of sharing ideas and working with others enhanced cooperation. Table 4 also shows a significant improvement in the interest factor of engagement, which could be attributed to the emphasis on pair activities and intense thinking about the topic while working on the task. According to Hidi & Harackiewicz (2000), when students are interested in the lesson, they are more likely to attend class, listen and participate, process information well, and eventually perform better. Like the cooperation and interest factors of engagement, the result in table 5 also indicates an improvement in the participation factor. This improvement seems to be attributed to the Google Docs think-pair-share activities in the OCL approach, as students had more opportunities to express themselves when they discussed and worked together. This result is consistent with the findings of Lee et al. (2018), who found that exposure to social interactions can help students improve their participation in the Think-pair-Share activity. Overall, the findings revealed that the OCL strategy significantly improved the students' engagement in terms of cooperation, interest, and participation factors in learning physical science. This supports the findings of Gopinathan et al. (2022) that there is a considerably significant relationship between digital collaboration tools, interaction, and motivation toward student engagement.

Meanwhile, the summary of the student responses to the Learning Experience Survey showed that students viewed OCL as a learning strategy positively, as most students reported improved performance and engagement. This result conforms with the findings of Al-Ammary (2013) that most students claimed that by participating in OCL, they felt more comfortable sharing their thoughts and comments. The result also backs up the findings of Othman et al. (2013) that students like to work in small groups to learn more effectively. Additionally, this is consistent with the study of Faulkner (2019), which showed that Google Docs promotes student learning by increasing opportunities for collaboration. Furthermore, this coincides with Ding and Harskamp (2011), who found that student participation in collaborative learning boosts student confidence and interest in science classes. Finally, the outcomes of this study confirmed the theory of Lev Vygotsky (1978), a famous social constructivist thinker, that one might achieve more depth comprehension than one's capacity by engaging with and learning from more knowledgeable peers.

Conclusion

This study determined the effects of the Online Collaborative Learning (OCL) strategy on student achievement and engagement. Based on the findings of this study, the following conclusions were drawn: (1) OCL strategy improved student achievement in physical science. (2) OCL strategy increased student engagement in learning physical science. (3) Cooperation, interest, and participation were the factors that prompted student engagement in learning Physical Science. (4) Students' positive responses to the OCL were evident during the implementation of the study.

Considering the positive effects of OCL in improving students' achievement and engagement, teachers are encouraged to adopt this pedagogical approach to teaching other topics in physical science as it was proven to improve student achievement and engagement. Further studies on OCL might be conducted in different science disciplines to improve 21st - century skills such as collaboration and communication across grade levels. Lastly, future studies might also employ other research designs, such as quasi-experimental, to generate more substantial data on the effectiveness of OCL strategy in science teaching and learning.

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Appendix A

Physical Science Achievement Test (Example)

1. Which of the following can determine a molecule's polarity?
   a. The number of electrons shared in the bond.
   b. The difference in atomic radius between the elements.
   c. The difference in first ionization energy between the elements.
   d. The difference in electronegativity between the elements.

12. Which of the following is true of intermolecular forces?
   a. The strongest force in chemistry.
   b. The forces that exist within molecules.
   c. The forces that exist between molecules.
   d. The force that bonds hydrogen and oxygen in water.

30. Why is cellulose so difficult for most animals to digest?
   a. Cellulose is made up of chitin, which is indigestible.
   b. There are many hydrogen bonds holding the subunits together.
   c. The bonds holding cellulose subunits together are extremely strong.
   d. They do not have the proper enzyme to break the bonds between subunits.

Appendix B

Cooperation, Interest, and Participation (CIP) Engagement Questionnaire

THE CIP ENGAGEMENT QUESTIONNAIRE

Directions: Please put a check mark (✓) on the column and rate yourself honestly based on what you know or do in the given statements below:

No.	Statements	Strongly Disagree (1)	Disagree (2)	Agree (3)	Strongly Agree (4)
1	Other students in my class like me the way I am.				
2	Other students at school care about me.				
3	Students at my class are there for me when I need them.				
4	Other students in our class respect what I have to say				
5	After finishing my schoolwork, I check it over to see if its correct.				
6	Most of what is important to know you learn in school.				
7	When I do schoolwork, I check to see whether I understand what I'm doing.				
8	When I do well in school it's because I work hard.				
9	The tests in my classes do a good job of measuring what I'm able to do.				
10	I feel like I have a say about what happens to me at school				
11	Learning is fun because I get better at something.				
12	What I'm learning in my classes will be important in my future.				
13	The grades in my classes do a good job of measuring what I'm able to do.				
14	I raise my hand whenever I have a question, inquiries and something to share about the lesson				
15	I enjoy talking and sharing ideas to the students in our class.				