Board Game-Aided Teaching Approach: Effects on Students' Conceptual Understanding in Chemistry

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ABSTRACT

Many students find Chemistry as one of the difficult subjects in secondary level as it is loaded with concepts that require not only understanding but also critical thinking and problem-solving skills. For this reason, the study aimed to investigate the effects of integrating board games in teaching Chemistry course. The research sample comprised of twenty-six (26) pairs of students from two intact classes of Grade 7 of Datu Mamintal Adiong Sr. Memorial National High School. They were matched according to the average of their First Quarter and Second Quarter Grades in Science during the school year 2023 to 2024. The students in the control group were exposed to conventional approach while the experimental group of students was exposed to board game-aided approach. The study utilized quasi-experiment with pretest-posttest control group design. Results revealed that experimental group of students' level of conceptual understanding after the intervention showed progress (7.7% satisfactory, 76.9 % very satisfactory and 15.4 % outstanding, respectively). Additionally, it was found that there was no significant difference ($p > .05$) between the Conceptual Understanding Test mean scores of experimental and control groups before ($t - value = .891$, $p - value = .377$) and after ($t - value = .510$, $p - value = .612$) the intervention. Also, the findings showed that there was no significant difference ($p > .05$) between the control and experimental groups of students' conceptual understating test mean gain score after the intervention. Thus, this study suggests that utilizing board games as an aid in teaching Chemistry concepts could still be helpful and applied since it does not bear negative outcomes to students' conceptual understanding. In line with these, the researcher encourages future researchers to conduct comprehensive study how can these board games be applied more productively.

Keywords: Board game-aided, conventional, conceptual understanding

INTRODUCTION

Appropriate and innovative pedagogical approaches, especially in science courses such as Chemistry, plays a crucial part in understanding various concepts and problem-solving tasks. Consequently, new teaching techniques, strategies, and instructional materials have emerged to meet the objectives and learning competencies prescribed in every topic domain.

One of the science courses found to be difficult by many high school students is Chemistry because it involves various concepts and calculations for some topics that require greater understanding and analysis. Chemistry curricula commonly incorporate many abstract concepts, which are central to further learning in both Chemistry and other sciences. Since learning science concepts are not easily understood by the students, abstract concepts are given much importance. The abstract nature of Chemistry along with other content learning difficulties (e.g. mathematical nature of Chemistry) means that Chemistry classes require a high-level skill set (Taber, 2002) and the contents of course topics that do not attract students' interest is one of the important problems in Chemistry education (Gilbert, 2006 as cited by Kara, 2019).

To address these challenges, the integration of board games has been explored as an innovative pedagogical approach. In recent years, there has been growing interest in exploring alternative educational tools to enhance conceptual understanding and students' knowledge retention. Among these tools, board games have gained recognition for their potential to promote engagement, collaboration, and critical thinking skills.

Some researchers argue that the fundamental motivation for all game is to learn, and it is a safe way to learn (Belanich, Sibley & Orvis, 2004), because games are effective substitutes for traditional classroom activities in educational settings of all levels (Ebener & Holzinger, 2007). Interestingly, the result of the study conducted by Wang, Wu and Hou (2019) indicated that the students in gamified learning activity showed significantly greater improvement than students in lecture-based teaching model (International Institute of Applied Informatics, 2019). Also, Orlik (2002) carried out a comprehensive study on active methodologies for the teaching of science in general, and chemistry in particular, and found out the use of games to be one of the most important approaches.

In addition, Collins and O'Brien (2003) highlighted that board games can effectively promote active learning by exposing learners in activities that encourage reflection on their ideas and their application.

This approach provides learners with opportunities to explore, understand concepts deeply, and determine the benefits of those concepts based on their capacities. Therefore, integrating board games into educational process can foster a more engaging and reflective learning environment, ultimately contributing to the development of lifelong learning skills.This has paved way for the researcher to conduct an experimental study to investigate the possible effects of board game-aided instruction to students' conceptual understanding and knowledge retention.

METHOD

This study used mixed method to investigate the effects of the board game-aided teaching approach on students' conceptual understanding in Chemistry. The quantitative aspects of this study used two intact groups to determine the student-participants' mean scores, mean gain scores and the significant difference in terms of their conceptual understanding in Chemistry. Specifically, the matching-only, pretest-posttest control group design were utilized.

The experimental group of students were taught with board game-aided teaching approach whereas the control group of students were taught using conventional teaching approach.

The subject participants in the study were twenty-six (26) paired students coming from two intact sections of Grade 7 enrolled at Datu Mamintal Adiong Sr. Memorial National High School for the School Year 2023-2024 and only two sections were needed for this quasi-experimental study.

The data gathering procedure in this study involved the necessary activities that were considered important in this study. This was divided into three (3) stages: Pre-Intervention Phase, Intervention Phase, and Post-Intervention Phase.

The Pre-Intervention Phase focused on the development of Chemistry Conceptual Understanding Test (CCUT) as research instruments, content validation and pilot-testing of instruments, preparation of lesson plans and development of board games instructional activities. The Chemistry Conceptual Understanding Test (CCUT) was a researcher-made questionnaire and comprised of 60-item multiple choice type of questionnaire with eight (8) open-ended questions attached to representative test items which was used as pretest and posttest. The open-ended questions were used to further assess how students grasp the topics incorporated in the questions but the answers for these questions were not graded.

The researcher utilized board games such as Snake & Ladder, 4-Pics, 1-word, and Jigsaw puzzle as supplementary instructional materials in teaching the Chemistry concepts. The intervention was completed from March until May of the school year 2024 wherein each group was met four hours per week. The results of the test of both groups were scored and recorded for analysis.

After the pretest, the teacher-researcher intervened by teaching the same topics, learning outcomes, and giving formative assessments to both groups however the aid of board games was exclusive for the experimental group. The control group was taught using conventional teaching approach.

After the intervention, posttest was administered to both groups of students. The posttest had the same contents as the pretest. Then, the data gathered were analyzed and interpreted using appropriate statistical tools.

The following statistical tools were used to analyze the data gathered, the results of which were the basis of rejection or acceptance of null hypotheses. The level of significance is set at $\alpha = .05$.

The descriptive statistics like the mean, frequency, percentage, and standard deviation was used to describe the raw score in Chemistry Conceptual Understanding Test (CCUT) in Chemistry of the control and experimental groups of students before and after intervention.

The Levene's test, t-test for the independent samples was used to determine significant difference between the mean scores and the mean gain scores of the control and experimental groups of students in CUT before and after the intervention.

FINDINGS AND DISCUSSION

The control and experimental groups' conceptual understanding in Chemistry topic domains of the study was assessed through their scores in the Chemistry Conceptual Understanding Test (CCUT). The conceptual understanding levels were categorized based on the scale adopted from DepEd Order No. 8 s.2015 such as "Did Not Meet Expectation", "Fairly Satisfactory", "Satisfactory", "Very Satisfactory", and "Outstanding". To specifically present the data, Table 2 is provided below.

Table 1:

Numbers and Percentage Distributions of Control and Experimental Groups of Student -participants' Conceptual Understanding Levels in Chemistry before and after the Intervention

Level of Conceptual Understanding	Before		After	
	Control (n=26)	Experimental (n=26)	Control (n=26)	Experimental (n=26)
Outstanding	0(0%)	0(0%)	10(38.46%)	10(38.46%)
Very Satisfactory	0(0%)	0(0%)	11(42.31%)	13(50.00%)
Satisfactory	0(0%)	0(0%)	5(19.23%)	3(11.54%)
Fairly Satisfactory	1(3.85%)	0(0%)	0(0%)	0(0%)
Did not meet expectation	25(96.15%)	26(100%)	0(0%)	0(0%)
Total	26(100%)	26(100%)	26(100%)	26(100%)

As shown in Table 1, before the intervention, most or 25 (96.15%) of the student- participants from control group fell under "Did not meet expectation" level while only 1 (3.85%) got a "fairly satisfactory." On the other hand, all or 26 (100%) of the student-participants in the experimental group fell under "Did not meet expectation" level. The results showed that majority of the student-participants from both groups have limited ideas on the topics Introduction to Science, Pure Substances and Mixtures, and Acid, Bases and Salts.

Nevertheless, after the intervention, both groups increased in their conceptual understanding level. It can be observed that the student-participants from the control group have reached "Satisfactory" 5 (19.23 %); "Very Satisfactory" 11 (42.31%); and "Outstanding" 10 (38.46%) levels, respectively. Similarly, the student-participants from the experimental group have achieved "Satisfactory" 3 (11.54%); "Very Satisfactory" 13 (50.00%); and "Outstanding" 10 (38.46%) levels, respectively. Moreover, none (0%) from both the control and experimental groups fell under "Did not meet expectation" and "Fairly Satisfactory" levels.

On the average, the control and experimental groups expressed positive outcome after intervention using conventional teaching approach (control group) and board game-aided teaching approach (experimental group). It is noteworthy that the conceptual understanding levelled up to “Very Satisfactory” and “Outstanding” and this can be attributed to the teaching approach applied to both groups.

Reflecting on the learning impacts of the conventional teaching approach combined with formative assessments, it is evident the traditional methods positively influence student-participants’ conceptual understanding. Through lectures, the student-participants received structured and comprehensive information that laid a solid foundation for their learning. The systematic delivery of content ensured that all key concepts were covered, providing student-participants with a clear framework of the subject matter. Evidently, the control group made significant improvement due to the inherent strengths of the conventional teaching approach, including structured learning, repetition, direct teacher interaction, and collaborative classroom dynamics.

Much like the improvement in the control group, the experimental group also benefited from the innovative approach of board games. Shanklin and Ehlen (2007) agreed that board games serve as a pedagogical tool that reinforces a positive environment for learning. Hussein et al. (2019) further documented how learners who were exposed to board game-based science learning showed improved cognitive gains in the mastering of topics related to life and living, matters and materials, energy and change and earth and beyond, compared to those learners who received traditional instruction. Wang, Wu and Hou (2019) also indicated that the student-participants in gamified learning activity showed significantly greater improvement than student-participants in lecture-based teaching model (International Institute of Applied Informatics, 2019).

To determine whether the variances of the control and experimental groups were comparable in terms of their conceptual understanding on the topic domains in Chemistry before the intervention, Levene’s Test was utilized. Moreover, to find out whether there is a significant difference between the control and experimental groups of student-participants’ conceptual understanding test mean score before and after the interventions as well as their mean gain score, a t-test for the independent samples was employed. To better illustrate this, Table 3 below shows the results of the statistical tests.

Table 2

Levene's Test and p values on the Comparison of Control and Experimental Groups of Student-participant-participants' Chemistry Conceptual Understanding Test (CCUT) Mean Scores before and the Mean Gain Score

Period	Group (n=26)	Levene's Test for equality of variances	Mean	Std. Deviation	t-value	p-value
Before	Control	.742	21.19	5.98	.891	.38(ns)
	Experimental	.393(ns)	19.84	4.84		
After	Control	.752	48.96	4.75	.510	.61(ns)
	Experimental	.390(ns)	49.58	3.90		
Mean Gain Score	Control	.002	27.77		-1.290	.20(ns)
	Experimental	.961	29.73			

Note. s=significant at .05 level, ns=not significant at .05 level

As shown in Table 2, before the intervention, both control and experimental groups demonstrated a closer mean score (21.19 and 19.84) with a t-test of .891 with a significant p-value of .38. This meant that the result is not significant; hence, there is no difference between the control and experimental groups of student-participants' conceptual understanding test mean score before intervention ($p > .05$). It can be depicted that the Levene's test result before the intervention is greater than .05 level of significance ($.393 > .05$). This means that the control and experimental groups are compared in terms of conceptual understanding. This is expected because student-participants have limited prior knowledge of the topic domains since this was not taught explicitly in their elementary science subjects.

Referring to the same table, it can also be observed that after the intervention, the t-test value is .510 and the p-value of .61 which is higher than .05 level of significance. This meant the result is not also significant; hence, there is no significant difference between the control and experimental groups' conceptual understanding test mean score. It can be noted that there is a difference of 0.62 between the mean score (48.96 vs. 49.58) of the control and experimental group, respectively. The result also implies that there is an increase in the mean scores of the two groups from 21.19 and 19.84 respectively before intervention.

Furthermore, the two groups demonstrated a closer mean gain score of 27.77 for the control group and 29.73 for the experimental group with a difference of 1.9 in favor of the latter. But statistically this result is not significant since its p-value is .20 which is higher than .05 level of significance. Despite of the insignificant result, this indicates that student-participants from both groups have progressed their conceptual understanding on the target topics which is evident from their mean gain scores.

The findings suggest that integrating board games may improve understanding of Chemistry concepts but does not guarantee that it is the sole cause for the mean gain scores of the student-participants in the post test. Lecture method, hands-on activities and viewing of related Chemistry videos could have also contributed to the cognitive aspects of the student-participants. Similarly, the study of Dalidig (2020) showed that there was no significant difference in the experimental group and control group' conceptual understanding on Chemistry topics before and after the intervention where board game was one of the tools used in game-based teaching approach. Hence, the integration of board games in teaching Chemistry has been explored as an innovative pedagogical approach, yet studies indicated that its impact on student-participant's conceptual understanding can be insignificant. This observation stemmed from several factors that limited the effectiveness of such games in deeply engaging student-participants with complex chemical concepts.

One critical issue is simplifying and focusing of single content topic in a board game. Board games, by design, need to simplify and condense information to fit gameplay mechanics. As a result, student-participants lack deeper understanding of the lesson. This is supported by the study of Siko and Barbour (2016) who found out that while educational games can enhance engagement and motivation, they frequently lack the depth require for a thorough understanding of scientific principle. Similarly, research by Kebritchi et al., (2010) highlighted that while games can support learning by providing interactive and engaging experiences, their impact on deep, conceptual learning is often limited compared to traditional instructional methods.

Besides, games can reinforce knowledge and bridge the gap between what is learned by creating dynamic, fun, and exciting learning environments (Royse and Newton 2007). They are a powerful teaching strategy, and they challenge and motivate student-participants to become more responsible for their own learning (Akl et al., 2013). However, this requires having the game to be well-designed and structured clearly with a framework that provides effective outcomes (Allery 2004).

Additionally, the contextual transfer of knowledge from game scenarios to real-world application can be problematic. Board games often place student-participants in hypothetical situations that, while engaging, they may not be able to grasp the desired learning goal. An empirical study by Sitzman (2011) emphasized that the contextual differences between game environments and real-world applications could obstruct the transfer of learning, resulting in only a marginal improvement in conceptual understanding.

Moreover, the dynamics of group play can also influence the learning outcomes. While collaboration is generally beneficial, the competitive nature of many board games can lead to unequal participation, where more knowledgeable or confident student-participants dominate, leaving others with minimal active engagement. This issue was noted in a study by Arnab et al. (2015) which found that while serious games are effective in fostering collaborative skills, they may not equally enhance individual conceptual understanding across all participants.

CONCLUSION

Based on the results of the study, the board game-aided teaching approach can be an effective way in addressing the problem on how students may understand deeper scientific concepts especially in Chemistry. Students engaged in both conventional and board game-aided teaching approaches showed improvement in their performance as can be observed in the difference of their pretest and posttest scores.

This study revealed that board game-aided teaching significantly enhanced student-participants' conceptual understanding level in Chemistry. The difference between students' scores in the pretest and posttest indicate marked improvements, showing that students taught through this method performed well in general than those who were taught using conventional approach. The variety of board games employed played a crucial role in achieving these outcomes.

Moreover, board games could enhance the teaching and learning process, as evidenced by various studies and related literature. Although board game-aided teaching approach proved effective for majority, there is still room for enhancement, particularly in ensuring that these learned concepts will be retained in their minds in longer time. Thus, researchers are encouraged to investigate the effect of integrating board games in teaching in a wider scope. Further study of the effectiveness of board games in education will help teachers to use them in the most effective way possible.

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