The Efficacy of Creative Play Approach in Teaching Modern Physics

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Abstract: Creativity plays a vital role towards active participation and student engagement. Different creative play approaches have been introduced, but these were mostly done in the primary years of education. In this paper, the authors presented creative plays in teaching Modern Physics concepts. Twenty-one students from 3 groups, G10, G11 and G12 were given instructions using the Creative Activities and Technologies (Science CAT) program. The games were the Rutherford Ball Toss Game (RBTG), Hidden Shapes Game (HSG) and the Radioactive Journey Board Game (RJBG). Each game was designed to enhance the following skills of the students, namely, conceptual understanding, analysis of evidence from given data, interpretation of symbols and equations, problem solving skills, and confidence in answering test questions.
This paper utilizes the normalized gain and effect size in analysing quantitative data. The qualitative data were gathered from interviews with the students and the classroom observations. A Cohen's **d = 63.1349** was noted from the comparison of the pre-test and post-test, denoting a high level of difference. Highest normalized gain **<g> = 0.5** was achieved by the RJBG on enhancing problem solving skills. The number of attempts in answering the achievement test increased compared to before the intervention. From the responses of the students, it was shown that the non-traditional and competitive nature of the play activities made it an effective tool in teaching modern physics to the student participants.

Key Words: creative play; modern physics; board game

1. INTRODUCTION

The Outcome Based Education (OBE) Framework was recently implemented in one of the authors' teaching institution. Aside from this, the institution also follows three international curricula or programs from Pre-School to Grade 12. Particularly, the science track follows the DepEd K-12 curriculum from pre- school to grade 6. For students from grades 7 to 8, the science curriculum is a merging of learning outcomes from both DepEd K-12 and Co-ordinated Science course of the International General Certificate of Secondary Education (IGCSE). This is to prepare them for the pure IGCSE program of grades 9 and 10. The outcomes set are meant to be treated as in a two-year long program. In grades 9 to 10 the IGCSE Co-Ordinated Sciences is offered, which is composed of Biology, Chemistry and Physics tracks taken all at the same time for 2 years. For grades 11 to 12 they can choose a biology, physics or chemistry track under the IB diploma program (IB DP).

The shift in the curricula as students progress from grade 10 to grade 11 resulted to gaps in the intended learning outcomes (ILOs). There were discrepancies in the pre-requisite skills needed to achieve the sophisticated mathematical operations and in depth analysis required in the grade 11 and 12 IB DP program.

Play incorporates active learning, and it is important in science learning for science activities itself requires on the spot experiential learning. Creative play was chosen due to it being able to present complex topics into simple game like formats which can help boost interest and motivation in the students. Creative play also concretely humanizes the perception of students toward science, in particular modern physics. Neathery (1997) determined an existing relationship between positive attitudes toward science to student performance and from her study she cited IAEP (1992), stating that positive student attitude is related for higher student achievement.

An intervention program to bridge the gap in the ILOs was created. The specific topics of the program were in higher level modern physics (atomic, nuclear and particle physics). The program was titled THE SCIENCE C.A.T. (Creative Activities and Technologies) Program.

The creative play activities in the SCIENCE C.A.T. program presented modern physics through simple creative applications or simulations in a form of a board game, puzzle and arcade play. Two of the creative play activities presented in the program were: (1) Rutherford Ball Toss Game (RBTG); and (2) Hidden Shapes Game (HSG). From the RBTG, students related their knowledge on the Rutherford experiment model to the game simulation model. Students then created their own understanding on how Rutherford and his team were able to come up with the conclusion that a nucleus exists. The HSG on the other hand involved several wooden shapes hidden under a wooden plank where students predicted the shape by letting marbles slide in it, incorporating the concepts under the Uncertainty Principle.

Vygotsky's Theory of Play, as interpreted by Nilsson and Ferholt (2014), described play as not only a prototype of everyday activity, and stated:

> "In real life action dominates meaning, but in play action is subordinate to meaning. It is only in play that the child can be strictly subordinated to rules, because it is in play that subordination to rules leads to pleasure"

Since in play subordination to rules is pleasurable, it then makes play activities as an effective and interesting activity for students to learn inherently complex topics in science and to achieve academically through play. Play gives a fresh perspective for learners, so as to efficiently deliver the topics creatively without sacrificing the main cognition of the topic. As stated by Smythe (2016), science at present is suffering from children not being given the right amount of opportunity to express themselves and to work and innovate on their own imagination.

In the SCIENCE C.A.T. program, the advanced physics topics and skills were presented to students through creative play approach. Figure 1 below presents how the said intervention program will be able to bridge the gaps in the ILOs due to the differences in program offered from grade 10 to grade 11-12.

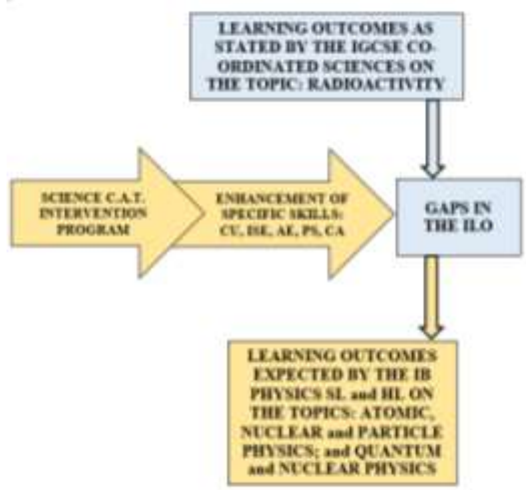

Fig. 1. Conceptual Framework of Creative Play

In general, the study followed on a theory that if creative play approach is used in teaching modern physics for grades 10, 11 and 12, students will develop conceptual understanding (CU), analysis of evidence from given data (AE), interpretation skills on modern physics symbols and equations

(ISE), problem solving skills (PS) and confidence in attempting to answer questions (CA) on topics under higher level modern physics. The creative play will then enable the SCIENCE C.A.T. program to be an effective bridging program on the ILO gaps in teaching modern physics concept for grade 10 to 12 students.

This study aimed to determine the level of improvement in the students' knowledge, analysis skills and interpretation of modern physics symbols and equations after the Science C.A.T program. Moreover, the students' lived experience, as well as that of the teacher's, during the 3 game play activities were discussed.

2. METHODOLOGY

This is a quasi-experimental study. The participants belonged to 3 groups: (1) 14 students from grade 10; (2) 5 students from grade 11B and; (3) 2 students from grade 12B.

The grade 10 students have recently taken topics on radioactivity, the grade 11B students were taking Higher Level physics and were just taught modern physics concepts, and the 12B students have recently taken topics on Quantum Mechanics, Particle Physics and Relativity.

Pre-test and post-test were administered to determine if there is an improvement in the knowledge of the students. The test questions used were based on past exam short-response questions from the IB Grade 12 past exams.

Class observation and semi-structured interview were performed as triangulation for the results obtained from the performance of the students in the conceptual test given at the end of the instruction. Quantitative data collected was interpreted using normalized gain <g> and effect size "d". Qualitative data was interpreted following a VCCT table (Verbatim – Category – Code – Theme).

The implementation of the program followed 5 phases of creative play. Within the two day implementation of the program, the two groups (grade 10 students in one group and grades 11B and 12B combined in the other) experienced the same activities. The day started with the first phase of planning and orientation. The student participants for the day were divided into smaller groups (preferably 5 maximum members). The pre-test was given to each student. An outside teacher observer was present throughout the implementation of the program. After the first phase, the students underwent a series of creative plays respectively: Rutherford Model Ball-Toss Game (Figure 2), Hidden Shapes Game (Figure 3) and Radioactive Journey Board Game. For the implementation, the 2 groups of IB students (Grade 11 and 12 students) played the games at the same time. The 4 groups of IGCSE students (Grade 10 students) followed a station rotation process wherein each group was assigned 1 station and after 20 minutes will have to rotate to the next station, until they encounter all stations. The 4 stations were: (1) Rutherford Ball Toss game (2) Hidden Shape: First Shape (3) Hidden Shape: Second Shape (4) Radioactive Journey Board Game. The station rotation represented the second to fourth phase of the Science C.A.T. program. The winners were acknowledged and the post-test was given afterwards. After the entire activity, a semi-structured interview was conducted with randomly selected students to describe their creative play experiences and how different do they think the creative play approach is from a regular lecture type of teaching and learning. Video recordings and interview with the teacher observer were gathered.


Fig. 2&3. Actual Rutherford Ball Toss Game (RBTG) (*left picture*) and Hidden Shapes Game (HSG) (*right picture*) during the implementation, as adapted from Luca (2017)

3. RESULTS AND DISCUSSION

Pretest and posttest scores of the students were compared. About 8 students had a moderate gain from their pre-test and post-test results, 9 students had a low gain and 4 students had a negative gain, meaning they scored lower in the post-test. Such negative gain can be related to the implementation time of the program (within the revision / external exam weeks) which then caused fragmented focus and could also have led to anxiety to their coming exams. All grade 11 and 12 student participants had a positive gain in their pre-test and post-test results, as compared to the grade 10 student results. One factor that could have affected the grade 10 having low gains was on the maturity level of the students in understanding the higher level concepts. The effective size "d" of the collected results was **d = 63.1349**, meaning the difference gained between the average scores of the pre-test (27) and post-test (37) was of high importance or effect (63.1349 > 0.5). However, 7 students had negative to no increase in the number of items answered, and 4 students had a decrease in the number of correctly answered items in the post-test. Even with the said results, only 3 students had a negative (decrease) in the number of items answered in the post test, 4 students with no change in amount of items answered and even 1 student who did not answer any item in the pre-test but answered almost all questions in the post-test.

Between the pre-test and post-test response on CU questions related to the RBTG, the <g> = 0.1 (low gain) and on AE question, the <g> = 0.4 (moderate gain). One reason that AE achieved a higher gain than CU was that CU requires further reading and more time in connecting data, while AE was concretely aided by the RBTG game simulation. In terms of the HSG related CU question, the <g> = 0.2 (low gain) and on ISE question the <g> = 0.1 (low gain). The results showed that even though the manual and game stated the Uncertainty principle, it was not enough to achieve a higher gain, adding to that was the topic being completely new to the grade 10 students.

Table 1: Summary of Results of Calculated Gains per Target Skill per Creative Game

Target Skill	Gain <g>	Parameter Level
	RBTG	
CU	0.1	Low gain
AE	0.4	Moderate Gain
	HSG	
CU	0.2	Low Gain
ISE	0.1	Low Gain

A summary of the scores of the grade 11 and 12 students on their modern physics assessments when they were in their grade 10 years and the scores of the current grade 10 participants on their scores in the modern physics assessment given after the implementation of the program were collected. A <g> = 0.2 was achieved (low gain) between the average of the scores of grade 10 during SY 2015-2016 and 2016-2017 against the average of scores of the current grade 10 students. Results still showed an improvement in terms of student achievement. In SY 2016-2017, student 11E got a 100 and the next highest was 81. In comparison with the grade 10 batch of SY 2017-2018, 2 students got even more than a hundred and the next highest scores were 93 and 91. Though there were some students who got an average score of 60 to 69 which affected gravely the average scores of the batch, more students were able to achieve 70 and up.

Qualitative data from interview responses and observations were gathered and organized in a VCCT table. Based from the student responses, most of the codes were the games are creative; fun; and contained hands-on experience. Categories were mostly on enjoyment leading to motivation gain; simulation of actual concept; and some categories of pleasure in winning; activation of prior knowledge; and use of imagination. In terms of the teacher observer, most of the code used from the responses were on fun and some on interest and recall. On categories, most were on enjoyment while learning.

In general, a high difference was achieved between the pre-test and post-test score of the 21 student participants. 4 students achieved lower in the post test due to: (1) distraction from the game being too much "game oriented"; (2) they have exams on the coming days and (3) two of them said they are more visual learners in which case in the post test only 2 diagrams can be seen. All <g> were positive, signifying that all games improved the skills, just not in the same level. CU skills improvement was the lowest from all 3 games, which might be connected on the nature of the skill requiring further reading and foundational concepts. Other skills improvement were different for each game. Most students viewed the program as a non-traditional approach to modern physics concepts, making the learning process fun, enjoyable, creative, hands-on, simulated activity, interesting, visual and pleasurable. Some of the responses were: "*cause its more hands on, and then so you can experience it for yourself in a way not necessarily going to like radioactive"* and *"That made it fun for people so they understood more"*. The short response results from the pre-test and post-test, showed improvement in terms of attempts, vocabulary, sentence construction and evidence of critical thinking. On the observational notes of the teacher observer, she stated that "*normally these kids would just sit down and listen (to a lecture) but (this time) they were very interactive and they were* *responsive. They asked questions. They were curious and they participated well".*

4. CONCLUSIONS

The SCIENCE C.A.T. program was able to enhance the analysis, interpretation and problem solving skills of the student participants. Low improvement was seen on the conceptual understanding of students. Improvement on physics vocabulary, construction of ideas, use of symbols and choice of words were evident from the pre-test and post-test responses. It was not a perfect enhancement but improvements can be seen and familiarity with the advance topics was already set in the students. Students mentioned that the creative play activities were able to help because of the competitive and fun nature of the games. Students also mentioned that the activities must not become too game oriented. Teacher observations mentioned that games as a teaching strategy can help make retention of knowledge longer and motivation higher. The SCIENCE C.A.T. then was a successful program, even though it did not meet high gains, it was able to develop 3 out of 5 skills with moderate gains, and all gains were positive, also the scores between the pre-test and post-test had a large positive difference.

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