

Development Of Cognitive Skills In Propositional Logic Through Wheel And Song Of Logic As A Supplementary Manipulative Among Humanities And Social Sciences Students

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ABSTRACT

To promote the implementation of manipulatives into mathematics instruction, this study was designed to investigate the efficacy of using the Wheel and Song of Logic in the development of six cognitive skills based from Bloom's Taxonomy as a supplementary manipulative in learning propositional logic among Humanities and Social Sciences students. The study sample comprised of 75 students from the two sections purposely selected from Grade 11 HUMSS in Magdiwang National High School of the School Year 2019-2020. Each group was taught the same topic which was propositional logic over a period of one month. However, the experimental group was taught using the supplementary manipulative, Wheel and Song of Logic, whilst the control group was taught using the explicit instruction. The instruments used for data collection were the validated propositional logic pre-test and post-test questions. The findings of the study were that, those who were taught with the supplementary manipulative performed significantly better especially in comprehension, analysis, synthesis and evaluation skills. Thus, the use of Wheel and Song of Logic proved to be a very effective and promising supplementary manipulative in learning propositional logic and that the said intervention also improved students' thinking process as they judiciously apply propositional logic in real-life arguments. On the basis of this findings, it is recommended that Wheel and Song of Logic should be used as a supplementary manipulative in learning propositional logic

Keywords

Cognitive Skills; Propositional Logic; Manipulative; Wheel and Song of Logic

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Introduction

Students often utter that learning is fun. This is the line of pupils and students if they find a certain subject striking, motivating, and realistic. Educators continuously aim to make classroom learning enjoyable and interesting to pupils and to students with mastery level of learning in their learning-process. Varied strategies have been taught and are being introduced like activity games, peer-coaching, group dynamic, songs, and e-learning. These are some ways by which the teaching and learning process can be made enjoyable and interesting.

Mathematics is a universal language and has long been recognized as the foundation of all sciences. Although most careers do not require higher mathematics, it is easy to forget how much mathematics is required in the most jobs. Carpenters use Geometry, Bookkeepers use Arithmetic, Entrepreneur and Merchants use Statistics and Engineers use Measurement as well as Scientists and other health related professions. Uses of this kind have been common for a long a time. Today, the use of advanced mathematics is also becoming more important in many careers.

Morrison [1] mentioned in his paper that gaining the basic mathematics knowledge is one of the imperative keys that will give the veracity to adapt from diverse society and fast-moving world. It is vital that every individual must be mathematically literate to cope with the changing world.

However, it is a sad reality that most students nowadays are facing difficulty in the field of mathematics.

In an International Research on Science and Mathematics Achievement as cited in the study of Morrison [1], it was

pointed out that Filipino students had the lowest performance in Mathematics. He also mentioned a statement from the Philippine Human Development Report that Filipino students obtained low scores in the standardized tests here and abroad. This statement is supported by the Third International Mathematics and Science Study (TIMSS) participated in by students worldwide, the result since 1995 to 2007 does not show any good standing about the country's performance both in Science and Mathematics. The mentioned results is somehow parallel with the National Achievement Test (NAT) results of the Magdiwang National High School in Mathematics subject which is far from 75% passing percentage in the previous years.

This is also one of the main reasons why educators are faced with the challenge of preparing young minds to utilize their fullest potential and ensure positions of responsibility in mastering the competencies in a world of Mathematics. To cope with the difficulty and obscurity faced by the students, Mathematics educators thought of using different strategies in teaching Mathematics to let every student learn and met the prerequisite skills or competencies as stipulated on the curriculum guide. One of those strategies and techniques is the use of manipulatives.

Ballado and Pelonia [2] stressed that a mathematics teacher needs to employ techniques and aids which will demystify the misconception that mathematics cannot be represented in the real world. One such technique is the use of manipulative, which are concrete objects that are designed to help students learn mathematics. The idea that young students learn best through interacting with concrete objects has sparked much interest in the use of mathematics manipulative. Ball [3] said that "Whether termed

manipulative, concrete materials, concrete objects, physical materials are widely touted as crucial to the improvement of mathematics learning". Modelling real life situations and abstract mathematics concept is the most striking advantage of physical manipulative in the mathematics classroom.

As cited in the study of Enki [4], mathematical concepts could often be very abstract for students and using manipulative materials will enable them to explore mathematical concepts in a concrete way. Manipulatives enable students to make connections between their own concrete sensory environment and more abstract levels of mathematics. He also mentioned that students are more active, their motivation for learning is higher and they adopt a positive attitude towards mathematics lesson when manipulatives are employed in mathematics classes.

In 2014, the National Council of Supervisors of Mathematics [5] issued a position statement on the use of manipulatives in classroom instruction to improve student achievement. "In order to develop every student's mathematical proficiency, leaders and teachers must systematically integrate the use of concrete and virtual manipulatives into classroom instruction at all grade levels.". This position is based on research supporting the use of manipulatives in classroom instruction. For example, studies of Fyfe et al [6] indicate that a systematic fading of concreteness can increase children's ability to transfer knowledge acquired through manipulatives to novel unfamiliar problems.

Propositional logic is one of the new contents in senior high school General Mathematics classroom that was introduced when the Enhanced Basic Education Act of 2013, RA 10533, was implemented. As experienced by the researcher, it is one of the least mastered topic in General Mathematics. This content was never been introduced nor discussed in junior high school mathematics content. They only have Number and Number sense, Measurements, Patterns and Algebra, Geometry, Statistics and Probability and Trigonometry. Students don't even have the prerequisite knowledge about its basics. The teacher-researcher devised a learning supplement which is a manipulative instructional material and wants to measure its effectiveness in learning propositional logic and mastering how to perform the different types of operations on propositions and to determine the truth values of the compound propositions being the one of the basics in learning logic and a learning competency on Logic content stipulated on the curriculum guide of General Mathematics.

Objectives

The main concern of the study is to determine the effect of Wheel and Song of Logic on the performance of Humanities and Social Sciences students of Magdiwang National High School in learning propositional logic in General Mathematics.

Specifically, this study attempts to answer the following questions:

1. How comparable are the two groups of Grade 11 Humanities and Social Sciences (HUMSS) students based from their first quarter grade in General Mathematics?

2. What is the pre-test performance of the two groups in terms of the following cognitive skills:

- 2.1. Knowledge?
- 2.2. Comprehension?
- 2.3. Application?
- 2.4. Analysis?
- 2.5. Synthesis?
- 2.6. Evaluation?

3. Is there a significant difference between the pre-test performances of the two groups?

4. What is the post-test performance of the two groups in terms of the following cognitive skills:

- 4.1. Knowledge?
- 4.2. Comprehension?
- 4.3. Application?
- 4.4. Analysis?
- 4.5. Synthesis?
- 4.6. Evaluation?

5. Is there a significant difference between the pre-test and post-test performance of each group?

6. Is there a significant difference between the post-test performances of the two groups?

7. What are the learning gains of the control and experimental group in terms of the following cognitive skills:

- 7.1. Knowledge?
- 7.2. Comprehension?
- 7.3. Application?
- 7.4. Analysis?
- 7.5. Synthesis?
- 7.6. Evaluation?

8. Is there a significant difference between the learning gains of the control and experimental group?

Methods

This research work used quasi-experimental pre-test-post-test design. A quasi-experiment is an empirical study used to estimate the causal impact of an intervention on its target population. Calmorin [7] said that it typically allow the researchers to control the assignment to the treatment condition, but using some criterion other than random assignment. It referred to the conceptual framework within which the experiment will be conducted. The researcher utilized the quasi-experimental method of research through pre-test and post-test to identify the effectiveness of the Wheel and Song of Logic in learning propositional logic.

This study used purposive sampling procedure in selecting the respondents. Purposive sampling is based on selecting individuals as samples according to the purpose of the researcher. An individual will be selected as part of the sample due to good evidence that he is a representative of the total population.

The respondents of this study were the Grade 11 Academic Track students of Magdiwang National High School, School Year 2019-2020. The respondents were the two intact and comparable sections of Humanities and Social Sciences (HUMSS) students with the least performance in General Mathematics during the first quarter.

This study focused on determining the effect of Wheel and Song of Logic on the scores obtained by the Grade 11

Humanities and Social Sciences senior high school students of Magdiwang National High School, School Year 2019-2020.

This study involved the two intact and comparable classes in the Humanities and Social Sciences of Grade 11 with the least average in General Mathematics during the first quarter from Magdiwang National High School in Magdiwang, Romblon. Their mean grades during the first quarter was considered to determine which class will be in experimental group and will be exposed to the intervention and the other class will be the control group and will be exposed to traditional instruction. The topics that were covered in this study will be under Logic as one of the content areas of General Mathematics. The manipulative instructional material can only be applied on those competencies and could not be used to other content areas and competencies. This was conducted during the first semester of the school year 2019-2020.

In this study, the researcher used pre-test and post-test questions to determine the efficacy of the Wheel and Song of Logic as a supplementary manipulative in learning propositional logic and lesson plans to be employed during the teaching and learning process.

Preparation. The researcher prepared the 30-item pre- and post-test questions that will be used in this study. Lesson plans were also prepared to be employed in teaching and learning process.

Validation. The test questions and the lesson plans that will be used in this study were subjected to validation to ensure that the material would serve its intended purpose of assessing the performance of the students in General Mathematics. It underwent content validity test and split-half reliability test. A pilot test was conducted to a group of Grade 12 students to establish item analysis and it resulted to an rtt of 0.731 for pre-test and 0.761 for post-test which were higher than 0.70 and interpreted as reliable. After that, revisions were made to some of the items that had been found to have a high level of difficulty and the test questions undergone final validation through critical evaluation of expert validators.

Writing of the First Draft. The items were all crafted according to the lesson competencies of the Deped K-12 General Mathematics curriculum guide. The research instruments were solely designed and crafted by the researcher.

Initial Validation. The initial test instrument output of this study was given to the validators for further validation purposes. The validators were given three days to examine the correctness of the concepts and principles and the construction of the test items.

Revision. The comments, suggestions and recommendations of the validators in the initial draft were the basis for the instruments' revision. Misconceptions as well as irrelevant items was deleted and replaced.

Final Validation. After the revision of the initial draft of the research instrument was completed, the revised material was then subjected to the validators for final validation.

Writing of the Final Draft. The researcher prepared the final draft of the research instrument.

Administration. The researcher himself was the one who administered the test questions to the Grade 11 Humanities

and Social Sciences General Mathematics students of Magdiwang National High School, School Year 2019-2020.

Validation of the Wheel and Song of Logic. The researcher administered the Wheel and Song of Logic to the experimental group, in which the learners manipulated the Wheel of Logic while singing the Song of Logic. Song of Logic is the researcher-composed song with content-enriched lyrics about propositional logic patterned to an existing hymn which was sung by the learners while manipulating the Wheel of Logic. Wheel of Logic is a concrete manipulative, specifically a spinner, which enable the learners to study and discover concepts in order to bring meaning to abstract ideas on propositional logic, performing the types of propositions and determining the truth values of compound propositions. This instructional material, categorized as manipulative, was validated by 3 experts from the school using the evaluation rating sheet for manipulatives stipulated on evaluation template on the guidelines and processes for LRMDs assessment and evaluation. Based on the rating sheet, 3 factors were evaluated: Factor A (content), Factor B (findings on the information with error) and Factor C (additional requirements for manipulative such as instructional and technical design). As examined, the material met a very satisfactory median result for each evaluation criterion. Even the administration of the material was observed by one of the validators using the classroom observation tool stipulated on the Philippine Professional Standards for Teachers (PPST). The effective use of the manipulative was evident as it was applied as a strategy in developing critical and creative thinking of the students (Indicator 3), engaged the learners in meaningful exploration, discovery and hands-on activities within a range of physical learning environments as they learn propositional logic (Indicator 4) and it was used appropriately as a teaching and learning resource in addressing learning goals (Indicator 8). Seven indicators were used during the observation and validation process and resulted to a perfect rating of 7, the highest point for a proficient teacher.

The data gathered in the researcher's instrument were computed with the use of the statistical tools. These statistics were used to measure and describe the variables in the study.

Arithmetic Mean. It was used to obtain the average of the students' scores.

Dependent samples t-test. It was used to measure the degree of significant difference between the pre-test and post-test mean scores of the control and experimental group.

Independent Samples t-test. It was used to determine the comparability of the control and experimental group on their pre-test and significant difference on the post test result.

Mean normalised learning Gain. This was used to determine the improvement in a student's learning between the beginning and end of the conduct of the study.

Mean Percentage Score Interpretation. It was used to determine the level of the students' scores in pre-test and post-test.

Score	Interpretation
25 – 3	Outstanding
19 – 24	Very Satisfactory
13 – 18	Satisfactory

7 – 12

Fairly Satisfactory

0 – 6

Did Not Meet Expectation

Percentage. This will be used to determine the performance level of the respondents in pre-test and post-test.

Standard Deviation. This will be used to give an idea on how the scores are scattered or part apart from each other.

Results & Discussions

For consistency and systematic presentation, the sequence of specific problems was followed in making the presentation, interpretation and analysis of data.

Comparability of the Academic Performance of the Two Groups in General Mathematics

Performance level indicates the extent of what the students have achieved in relation to what is expected of them. In the study, the first quarter grade of Grade 11 Humanities and Social Sciences Students in Magdiwang National High School for school year 2019 – 2020 in General Mathematics for Grade 11 were collected.

Table 1. Comparison of the Two Groups based from First Quarter Grade in General Mathematics

Grp	Mean	SD	t	CV	Decision	Interpretation
Humss 2	81.78	5.07	0.06	1.99	Failed to Reject Ho	Not Significant
Humss 3	81.71	3.22				

Table 1 shows the comparison of the first quarter grade in General Mathematics of the two sections of Grade 11 HUMSS students in Magdiwang National High School for School Year 2019 – 2020.

It can be shown in the table that the difference between the first quarter grades obtained by the two sections resulted a significant difference of 0.06 which is less than the tabular value of 1.99 at 0.05 level of significance with a degree of freedom of 73. Hence, the hypothesis that there is no significant difference between the first quarter grades of the two groups was confirmed. This indicates that the academic performance of the two groups are comparable and coherent before the conduct of the study.

Pre-test Performance of the Two Groups

Table 2. Summary of Pre-test of the Two Groups

Cognitive Skills	Control			Experimental		
	Mean	SD	Description	Mean	SD	Description
Knowledge	1.11	0.66	DNME	1.37	1.24	DNME
Comprehension	1.08	0.89	DNME	1.29	0.87	DNME
Application	1.54	0.99	FS	1.42	1.06	DNME
Analysis	1.68	1.08	FS	1.32	0.90	DNME
Synthesis	0.00	0.00	DNME	0.00	0.00	DNME
Evaluation	2.24	1.34	FS	1.95	1.18	FS
Over-all	7.43	1.94	FS	7.55	2.13	FS

Table 2 presents the summary of the pre-test performance of the two groups in six cognitive skills based on Bloom's Taxonomy.

As presented in the table, the performance of the respondents in control group on knowledge, comprehension and synthesis could be described as being in the "did not meet expectations" category while in application, analysis

and evaluation, they belonged to "fairly satisfactory" category. The over-all mean of 7.43 signifies that the control group has a fairly satisfactory performance in pre-test with a standard deviation of 1.94.

On the other hand, the performance of the respondents in experimental group on knowledge, comprehension, application, analysis and synthesis landed in "did not meet expectation" category while their performance on evaluation falls in "fairly satisfactory" category. The over-all mean of 7.55 indicates that the experimental group has a fairly satisfactory performance in pre-test with a standard deviation of 2.13.

The data imply that both groups were at the same level at the start of the study, therefore, they are comparable. This meets the requirement of an experimental study which states that both groups must be comparable or no group is better than the other when used in an experimental investigation.

Difference between the Pre-test Performance of the Control and Experimental Group in the Six Cognitive Skills

Table 3. Test of Difference between Pre-test Performances of the Two Groups

Cognitive Skills	Control		Experimental		t	CV	Description	Decision
	Mean	SD	Mean	SD				
Knowledge	1.11	0.66	1.37	1.24	1.13	1.99	Not Sig	Failed to Reject Ho
Comprehension	1.08	0.89	1.29	0.87	1.02	1.99	Not Sig	Failed to Reject Ho
Application	1.54	0.99	1.42	1.06	0.51	1.99	Not Sig	Failed to Reject Ho
Analysis	1.68	1.08	1.32	0.90	1.57	1.99	Not Sig	Failed to Reject Ho
Synthesis	0.00	0.00	0.00	0.00	0.00	1.99	Not Sig	Failed to Reject Ho
Evaluation	2.24	1.34	1.95	1.18	1.01	1.99	Not Sig	Failed to Reject Ho
Over-all	7.43	1.94	7.55	2.13	0.26	1.99	Not Sig	Failed to Reject Ho

Table 3 shows the test of difference between the pre-test performances of the two groups.

Overall, the difference between the pre-test performances of the two groups resulted to a significant difference of 0.26 which was less than the tabular value of 1.99 at 0.05 level of significance with a degree of freedom of 73. Hence, the hypothesis that there is no significant difference on the performance level of the control and experimental group in pre-test was confirmed. This indicates that the two groups were at the same level at the start of the study and that their performances were comparable and coherent before the exposure of the Wheel and Song of Logic in learning propositional logic.

Post-test Performance of the Two Groups

Table 4. Summary of Post-test of the Two Groups

Cognitive Skills	Control			Experimental		
	Mean	SD	Description	Mean	SD	Description
Knowledge	3.16	0.99	S	3.89	0.61	VS
Comprehension	4.59	0.60	O	4.89	0.31	O
Application	4.46	0.80	VS	4.16	0.89	VS
Analysis	3.38	1.23	S	4.55	0.65	O
Synthesis	3.38	1.23	S	2.61	0.97	S
Evaluation	2.41	1.17	FS	4.05	1.06	VS
Over-all	21.73	3.42	VS	24.16	2.50	VS

Table 4 presents the summary of the post-test performance of the two groups in six cognitive skills based on Bloom's Taxonomy.

As presented in the table, the performance of the respondents in control group on knowledge, analysis and synthesis landed in "satisfactory" category while their performance on comprehension, application and evaluation falls in "outstanding", "very satisfactory" and "fairly satisfactory" category, respectively. The over-all mean of 21.73 signifies that the control group had a very satisfactory performance in post-test with a standard deviation of 3.42.

For the performance of the respondents in experimental group on knowledge, application and evaluation, it can be seen in the table that they have "very satisfactory" performance while on comprehension and analysis, they were described as "outstanding". The over-all mean of 21.46 signifies that the experimental group had a very satisfactory performance in post-test with a standard deviation of 2.50.

It can be noted that both groups obtained the highest mean score on the items measuring comprehension skill. When interviewed, the learners perceived that those items were easy to answer. Learners in experimental group perceived that the Song of Logic, especially its lyrics and pattern presented, was helpful in answering the test items. As propositional logic requires analysis, Wheel of Logic made it easy for them and they thought of not reviewing because they already memorized the Song of Logic and perceived to be helpful in answering the items measuring the comprehension skill.

The data imply that after the utilization of Wheel and Song of Logic in learning propositional logic, the performance of experimental group differed in control group, revealing that the experimental group had higher performance than control group.

Difference between the Pre-test and Post-test Performances of Each Group

Table 5. Test of Difference Between the Pre-test and Post-test Performance of Each Group

Cognitive Skills	Pre-Test		Post Test		Computed t	Tabular t at 0.05	Description	Decision
	Mean	SD	Mean	SD				
CONTROL								
Knowledge	0.89	0.81	3.16	0.99	9.95	2.03	Significant	Reject Ho
Comprehension	1.08	0.89	4.59	0.60	21.01	2.03	Significant	Reject Ho
Application	1.54	0.99	4.46	0.80	13.30	2.03	Significant	Reject Ho
Analysis	1.68	1.08	3.73	1.24	7.29	2.03	Significant	Reject Ho
Synthesis	0.00	0.00	3.38	3.90	16.67	2.03	Significant	Reject Ho
Evaluation	2.24	1.34	2.41	1.17	0.56	2.03	Not Sig	Failed to Reject Ho
Over-all	7.43	1.94	21.73	3.42	22.10	2.03	Significant	Reject Ho
EXPERIMENTAL								
Knowledge	1.37	1.24	3.89	0.61	11.37	2.03	Significant	Reject Ho
Comprehension	1.29	0.87	4.89	0.31	23.50	2.03	Significant	Reject Ho
Analysis	1.42	1.06	4.16	0.89	10.74	2.03	Significant	Reject Ho
Analysis	1.32	0.90	4.55	0.65	17.73	2.03	Significant	Reject Ho
Synthesis	0.00	0.00	2.61	0.97	16.49	2.03	Significant	Reject Ho
Evaluation	1.95	1.18	4.05	1.06	7.99	2.03	Significant	Reject Ho
Over-all	7.55	2.13	24.16	2.50	32.41	2.03	Significant	Reject Ho

Table 5 reveals the result of the test of significant difference between the pre-test and post-test performance of the control and experimental group.

As revealed on the table, the performance of the respondents in control group in all six cognitive skills resulted to computed t-values which are greater than the tabular value of 2.03 at 0.05 level of significance with a degree of freedom of 36. This means that there is a significant difference between the pre-test and post-test performance of the respondents to all six cognitive skills. Overall, the difference between the pre-test and post-test performance of control group resulted to a significant difference of 22.10 which is greater than the tabular value of 2.03 at 0.05 level of significance with a degree of freedom of 36. Hence, the hypothesis that there is no significant difference between the pre-test and post-test performance of the respondents in control group was disconfirmed.

With that data, it can be implied that the traditional instruction utilized by the researcher in teaching propositional logic had helped improved the performance of the students in control group. This is consistent with the results of the study of Morron [1] that there had been an increase in the performance of the students when taught using traditional instruction.

On the other hand, the performance of the respondents in experimental group to all six cognitive skills resulted to a significant difference which is greater than the tabular value of 2.03 at 0.05 level of significance with a degree of freedom of 37. This means that there is a significant difference between the pre-test and post-test performance of the respondents to all six cognitive skills. Overall, the difference between the pre-test and post-test performance of experimental group resulted to a significant difference of 32.41 which is greater than the tabular value of 2.03 at 0.05 level of significance with a degree of freedom of 37. Hence, the hypothesis that there is no significant difference between the pre-test and post-test performance of the respondents in experimental group was disconfirmed. This indicates that the utilization of Wheel and Song of Logic in learning propositional logic had helped improve the performance of the students in experimental group.

The data convey that there is an increase in the scores of the students exposed both in Wheel and Song of Logic and traditional instruction alone based on the pre-test and post-test results.

The aforementioned result affirmed the findings of Hendriana, et. al. [8] that the use of manipulative improved the students' mathematical ability and self-confidence. It can be attributed to learning the concept while doing some actual manipulation of materials. As Confucius said, a person learns when he does an activity.

Difference between the Post-test Performance of the Control and Experimental Group in Six Cognitive Skills

Table 6 shows the the test of difference between the post-test performances of the two groups.

As shown in the table, the difference between the post-test performance of the control and experimental group on knowledge, comprehension, analysis, synthesis and evaluation resulted to significant differences which are

greater than the tabular value of 1.99 at 0.05 level of significance with a degree of freedom of 73. This means that there is a significant difference between the post-test performances of the two groups on five mentioned cognitive skills. Overall, the difference between the post-test performances of the two groups resulted to a significant difference of 3.52 which is greater than the tabular value of 1.99 at 0.05 level of significance with a degree of freedom of 73. Hence, the null hypothesis that there is no significant difference between the performance level of the control and experimental group was disconfirmed. This indicates that after the utilization of Wheel and Song of Logic in learning propositional logic, the performance of the experimental group differed significantly with that of the control group.

Table 6. Test of Difference between the Post-test Performances of the Two Groups

Cognitive Skills	Control		Experimental		t	CV	Description	Decision
	Mean	SD	Mean	SD				
Knowledge	3.16	0.99	3.89	0.61	3.89	1.99	Sig	Reject Ho
Comprehension	4.59	0.60	4.89	0.31	2.73	1.99	Sig	Reject Ho
Application	4.46	0.80	4.16	0.89	1.54	1.99	Not Sig	Failed to Reject Ho
Analysis	3.73	1.24	4.55	0.65	3.62	1.99	Sig	Reject Ho
Synthesis	3.38	1.23	2.61	0.97	3.02	1.99	Sig	Reject Ho
Evaluation	2.41	1.17	4.05	1.06	6.39	1.99	Sig	Reject Ho
Over-all	21.73	3.42	24.16	2.50	3.52	1.99	Sig	Reject Ho

This agrees with the findings of Liggett [9] that the group of students who was presented with the opportunity to use manipulative obtained higher scores in comparison to other group who did not use manipulative. In the present study, the learners enjoyed the lesson as the learning was facilitated by the teacher. They thought of Wheel and Song of Logic was helpful in mastering the concepts on propositional logic and it made them become interested during the discussion. When interviewed, the learners are thinking that the Wheel and Song of Logic made them easier to discover the concepts on propositional logic through an enjoying way. They enjoyed it very much as the manipulative was administered and implemented using varied strategies, such as individual activities and collaboration. The lyrics of the song served as the guide for the learners to master the concept. They perceived that learning the lesson through singing would be easier than just merely discussing and lecturing it.

Learning Gains of the Control and Experimental Group

Learning gain is the percentage of increment in the learning of the student from pre-test to post-test. It is expressed in percentage.

Table 7. Summary of Learning Gains of the Two Groups

Cognitive Skills	Control		Experimental	
	Mean	SD	Mean	SD
Knowledge	52.66%	27.58%	63.20%	25.35%
Comprehension	89.41%	15.81%	96.93%	9.17%
Application	82.12%	31.62%	68.95%	40.99%
Analysis	56.31%	43.10%	87.11%	19.01%

Synthesis	67.57%	24.65%	52.11%	19.47%
Evaluation	-6.35%	68.06%	61.58%	54.70%
Over-all	63.06%	15.51%	73.81%	11.21%

Table 7 illustrates the summary of the learning gains of the two groups in six cognitive skills based on Bloom's Taxonomy.

As illustrated in the table, the experimental group registered a learning gain of 73.81% while the control group got 63.06% as their learning gains. Comparatively speaking, the experimental group did better than the control group. This implies that the use of Wheel and Song of Logic contributed more in the learning of propositional logic. This is due to the fact that the students in experimental group were able to discover concepts on the types of propositions and its truth values using the Wheel and Song of Logic, a teaching technique where manipulative materials are provided to the students.

Difference between the Learning Gains of the Control and Experimental Group

Table 8 provides the learning gains of the two groups and the result of the test of significant difference existed between them.

As provided in the table, the difference between the learning gain of the control and experimental group on comprehension, analysis, synthesis and evaluation resulted a computed t-value which was greater than the tabular value of 1.99 at 0.05 level of significance with a degree of freedom of 73. This means that there is a significant difference between the learning gains of the two groups on the mentioned cognitive skills.

Overall, the difference between the learning gains of the control and experimental group resulted a computed t-value of 3.45 which was absolutely greater than the tabular value of 1.99 at 0.05 level of significance with a degree of freedom of 73. Hence, the hypothesis that there is no significant difference between the learning gains of the two groups was refuted. This indicates that after the utilization of Wheel and Song of Logic in learning propositional logic, learning achievements of the students in experimental group was better than control group. This can be attributed to the fact that the learners in experimental group were provided with the opportunity of discovering the concepts in propositional logic using the Wheel and Song of Logic. This proves that the manipulative has been effective in reinforcing, enriching and leading to the mastery of the content for the level of the students as well as the topic, propositional logic.

The result is somehow parallel to the findings of Hendriana, et. al. [8] that the students who were provided the opportunity to use mathematical manipulative was better than the group of students taught by conventional teaching.

Table 8. Difference between the Learning Gains of the Control and Experimental Group

Cognitive Skills	Control		Experimental		t	CV	Description	Decision
	Mean	SD	Mean	SD				
Knowledge	52.66 %	27.58 %	63.20 %	25.35 %	1.72	1.99	Not Sig	Failed to Reject Ho
Comprehension	89.41 %	15.81 %	96.93 %	9.17 %	2.53	1.99	Significant	Reject Ho
Application	82.12 %	31.62 %	68.95 %	40.99 %	1.55	1.99	Not Sig	Failed to Reject Ho
Analysis	56.31 %	43.10 %	87.11 %	19.01 %	4.02	1.99	Significant	Reject Ho
Synthesis	67.57 %	24.65 %	52.11 %	19.47 %	3.02	1.99	Significant	Reject Ho
Evaluation	- 6.35 %	68.06 %	61.58 %	54.70 %	4.77	1.99	Significant	Reject Ho
Over-all	63.06 %	15.51 %	73.81 %	11.21 %	3.45	1.99	Significant	Reject Ho

Conclusion

Based on the results and discussion, the following conclusions were drawn:

1. Both groups have increased their knowledge about propositional logic, regardless of what teaching technique was employed.
2. The performance of the two groups differs significantly from pre-test to post-test and that Wheel and Song of Logic and Nonwheel and Song of Logic instruction have positive impact in improving the performance of the students.
3. The utilization of Wheel and Song of Logic and proves to be a promising teaching technique in learning propositional logic. Generally, the use of Wheel and Song of Logic contributes more to the learning of "propositional logic" specifically in comprehension, analysis, synthesis and evaluation skills compared to the non-wheel and song of logic.

Limitations and Future Studies

Based on the conclusions made, the following recommendations were given:

1. General Mathematics teachers may use the Wheel and Song of Logic devised by the researcher as a teaching technique in discussing propositional logic.
2. General Mathematics teachers who will be using the Wheel and Song of Logic should be innovative by giving activities which are related to learners' experiences.
3. General Mathematics teachers are encouraged to use the Wheel and Song of Logic integrating technology with related materials to make it a virtual manipulative and interactive instructional approach in teaching to increase the learning achievement of the learners.
4. Since the devised manipulative was found effective, teachers are encouraged to devise their own manipulatives in teaching any concept in mathematics. Future researchers may conduct parallel study devising their own manipulative in teaching other areas

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