

Utilizing Normal Curve Slider in Statistics and Probability: A Quantitative Investigation

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ABSTRACT:

Instructional materials are vital elements of teaching and learning situations. They serve not only to enhance learning, but also to improve the entire process. This study aimed to assess the efficacy of the normal curve slider in enhancing the acquisition of competencies related to normal distribution in the field of Statistics and Probability. The slider intervention was implemented in a specific area of the Humanities and Social Sciences department at Notre Dame Village National High School before the onset of the COVID-19 pandemic. A quantitative research design was employed, using a quasi-experiment and survey method. The study's findings indicated that in the post-test, 46% of the respondents achieved high scores in lower-order thinking skills (LOTS), compared to their scores of 0% in the pretest. Similarly, in higher-order thinking skills (HOTS), 56% of the respondents obtained average scores, which represented an improvement from their pretest scores of 22%. Furthermore, there was a substantial increase in both overall and specific performance levels before and after the intervention, indicating that the intervention was effective. During the validation process, it was determined that students have a favorable disposition towards the use of normal curve sliders. The slider enhances the understanding of the normal curve lessons, encompassing both LOTS and HOTS. Furthermore, the use of a slider can significantly augment both motivation and learning outcomes, even among senior high school students.

KEYWORDS:

normal curve slider, normal distribution, quasi-experiment, survey, Philippines.

INTRODUCTION

Educators consistently strive for the optimal outcomes for their students. Learners exhibit varying degrees of motivation, distinct attitudes towards teaching and learning, and varied responses to specific classroom environments and instructional methods. Teachers who possess a comprehensive understanding of the differences are more likely to effectively address the varied learning needs of their students [1]. An essential priority in school Mathematics is to place emphasis on familiarity in mathematical learning. Teachers have access to multiple resources that will help the development of students' mathematical learning. Manipulatives are extensively utilized as valuable mathematical tools that facilitate experiential learning through the use of tangible objects [2].

Several state standards, including the Florida Math Standards, the Common Core Math Standards, and the National Council for Teachers of Mathematics, advocate for the incorporation of representational models as a crucial component of mathematics training. Representations can be understood using various forms, including graphics, digital manipulatives, and tangible hands-on didactics [3]. In the study conducted by [2], it was highlighted that learning tools, such as manipulatives, typically wield a more favorable influence on students' learning and mathematics achievement than traditional methods of instruction, which frequently rely on worksheets and computational fluency.

Manipulatives have been utilized for decades in primary and early elementary education. As students advance through the later stages of elementary and middle school Mathematics, it is crucial for teaching resources to consistently incorporate manipulatives. The fundamental approach – direct engagement with objects – is straightforward, although has been used across various mathematical topics with encouraging outcomes [4].

Statistics and Probability is a basic course that must be completed by Senior High School (SHS) students across all tracks. Mathematics is frequently recognized as one of the most challenging subjects faced by students and adults alike. Mathematical difficulties are prevalent in both boys and girls, unlike challenges in language and literacy [5]. In the study conducted by [6], many learners encountered challenges in solving probability problems and struggled to implement various probability ideas in these situations. Consequently, the researchers developed an alternative manipulative called the Normal Curve Slider to enhance students' proficiency in normal distribution within the realm of Statistics and Probability.

Objectives of the Study

This study sought to evaluate the efficacy of the normal curve slider in enhancing normal distribution competencies in Statistics and Probability among Humanities and Social Sciences students at Notre Dame Village National High School. The study aimed to find out the pre- and post-performances of users of the normal curve slider in normal distribution competencies, focusing on lower-order thinking skills (LOTS) and higher-order thinking skills (HOTS). It investigated whether there is a significant difference between students' pre- and post-performances categorized into LOTS and HOTS, as well as the differences in their post-performance within LOTS and HOTS, and assessed students' attitude towards the use of the normal curve slider.

Theoretical Framework

This investigation was based on the constructivist idea. Jean Piaget's constructivist theory (1952) influences educational curricula by necessitating that educators develop plans that promote their students' logical and conceptual development. Educators must underscore the vital importance of experiences or ties with the surrounding environment in the learning process for students. The role of educators is crucial. Rather of delivering a lecture, educators in this framework act as facilitators, assisting students in their comprehension. Learning is an active process wherein individuals acquire knowledge within a meaningful context. Constructivism occurs when the educator administers performance-based assessments, aids learners in processing their comprehension of the material, and enhances their learning through innovative methods to ensure effective and successful teaching and learning.

METHODOLOGY

Research Design

The study employed a purely quantitative design utilizing quasi-experimental and survey methodologies. A quasi-experimental approach, specifically using pre and post-tests, was conducted initially, followed by

a survey. These were utilized to assess the efficacy of the normal curve slider in acquiring skills related to normal distribution within Statistics and Probability.

Instrumentation

The study utilized teacher-created pre and post-tests together with a survey questionnaire. The researchers developed a three-dimensional manipulative for Statistics and Probability called the normal curve slider. Fifteen semi-detailed lesson plans were developed in accordance with the guidelines established by the Department of Education (DepEd) for the demonstration teaching. The lesson plan consisted of five components: objective, subject matter, procedure, evaluation, and agreement. The technique was subdivided into preparation, activity, analysis, abstraction, and application. The two tests are accompanied by a table of specifications designed in accordance with the DepEd format, incorporating the competencies of normal distribution as outlined in the DepEd curriculum guide for Senior High School Statistics and Probability. Furthermore, the first and second tests consisted of 30 multiple-choice items each, grounded on Bloom's Taxonomy (1985), encompassing both lower-order thinking skills (knowledge, comprehension and application) and higher-order thinking skills (analysis). The panelists together with Statistics and Probability instructors validated these tests while the reliability test was done at Cotabato City National High School-Main Campus involving 20 randomly selected HUMSS students.

On the other hand, the normal curve slider was a three-dimensional manipulative available in two sizes: small and large. The large structure was constructed using static wood, mobile cardboard, fabric, and other artworks created with acrylic paints. Conversely, the small version was constructed using fabric and styrofoam, coated with acrylic paints. In addition to the physical attributes of the slider that might enhance student learning, it possesses two more distinctive applications. The basic level can be utilized to illustrate the history and define a normal curve, discuss its properties, present standardized normal distribution, and facilitate comprehension of the areas beneath a normal curve. One of its features is the inclusion of the z-table, which allows students to optimize the slider and enhance their skills in calculating probabilities across various ranges or intervals of standard scores (z-scores). At an advanced level, it facilitates the more efficient change of word problems related to regions or probabilities beneath a normal curve. For the survey questionnaire, it consisted of 15 questions designed to assess students' attitude towards the use of the normal curve slider, based on Lefton (1997), encompassing cognitive, emotional and behavioral components.

Procedure

The researchers asked consent from the NDVNHS administration to perform the study. The pre-test was administered initially, followed by a demonstration teaching over three consecutive weeks (15 days), culminating in a post-test. The demonstration teaching for LOTS occurred over 7 days, while the subsequent 8 days were designated for HOTS. The researchers ensured that all respondents had direct experience with both the large normal curve slider and the smaller one. This was promptly succeeded by the administration of a survey. The researchers employed the Jeffreys' Amazing Statistics Program (JASP) for data analysis. Frequency, percentage, mean, and standard deviation were employed for the initial two research questions. For the third research question, multivariate analysis of variance (MANOVA) was employed to ascertain whether a significant difference exists between the pre- and post-performance of students categorized into LOTS and HOTS. A dependent or paired t-test was employed to ascertain whether a significant difference exists between the post-performances of students in LOTS and HOTS for the fourth research question. At a significance threshold of 0.05, the means of the compared variables were assessed for statistical significance. The determination of significance depends on the p-value reported by JASP; if the p-value is less than α ($\alpha = 0.05$), it is deemed significant, indicating the rejection of the null hypothesis. The mean and standard deviation were employed for the final research question.

RESULTS AND DISCUSSION

Pre and Post - Performances in Normal Distribution Competencies

The pre- and post-performances of HUMSS students in normal distribution competencies within Statistics and Probability, specifically at the levels of LOTS and HOTS, are illustrated in Tables 1 and 2, respectively.

Table 1 shows that thirty-seven (37) out of fifty (50), or 74% of the respondents, achieved scores between 6 and 11 on the pre-test, categorized as low scores. This was succeeded by 8 or 16% achieving average scores, 5 or 10% obtaining very low scores, and none attaining high or very high scores, respectively. The data in the same table indicates that following the introduction of the normal curve slider intervention, the post-test results showed that twenty-three (23) out of 50 or 46% of the respondents, achieved scores within the range of 18 to 23, categorized as high scores. Furthermore, 15 or 30% of them achieved scores categorized as average, while 5 or 10% obtained low scores. Seven (7), representing 14%, achieved exceptionally high scores, while no respondent scored within the very low range.

Table 1.
Pre and Post - Performances of HUMSS Students under LOTS

Range of Scores	Pre - Performance		Post - Performance		Description
	<i>f</i>	<i>f</i> %	<i>f</i>	<i>f</i> %	
24 - 30	0	0.0	7	14.0	Very High Score
18 - 23	0	0.0	23	46.0	High Score
12 - 17	8	16.0	15	30.0	Average Score
6 - 11	37	74.0	5	10.0	Low Score
0 - 5	5	10.0	0	0.0	Very Low Score
		$\bar{x} = 8.88$		$\bar{x} = 18.22$	
Total	50	100.0	50	100.0	

The findings indicate that nearly 85% of the respondents scored below average (0 - 11), with no individuals achieving above average (23 - 30) in the pre-test. Conversely, merely 10% of them fall below normal, while 60% exceed average in the post-test. This indicates an enhancement in scores from pre-test to post-test, evidenced by the means of 8.88 and 18.22. Accordingly, numerous students struggle to comprehend probability and statistical concepts, as evidenced in various educational settings. Many studies have concentrated on identifying models incorporating non-cognitive elements, such as attitudes and emotions around Statistics, to enhance the comprehension of the mechanisms underpinning Statistics accomplishment [7]. The emphasis is on the instructional methodologies and conventional curricular materials employed in Statistics courses, which have shown ineffective in fostering conceptual comprehension of Statistics topics [8].

Table 2.
Pre and Post - Performances of HUMSS Students under HOTS

Range of Scores	Pre - Performance		Post - Performance		Description
	<i>f</i>	<i>f</i> %	<i>f</i>	<i>f</i> %	
24 - 30	0	0.0	3	6.0	Very High Score
18 - 23	0	0.0	3	6.0	High Score
12 - 17	11	22.0	28	56.0	Average Score
6 - 11	33	66.0	14	28.0	Low Score
0 - 5	6	12.0	2	4.0	Very Low Score
		$\bar{x} = 9.26$		$\bar{x} = 13.86$	
Total	50	100.0	50	100.0	

Table 2 reveals that thirty-three (33) out of fifty (50), or 66%, of the respondents achieved scores between 6 and 11 on the pre-test, categorized as low scores. Subsequently, 11 or 22% achieved average scores, 6

or 12% received very low scores, and none attained high or very high scores, respectively. The same table indicates that with the introduction of the normal curve slider intervention, the post-test results revealed that twenty-eight (28) out of 50 participants, or 56%, achieved scores within the range of 12 to 17, classified as average scores. Additionally, 14 or 28% of the participants achieved scores categorized as low, while three (3) or 6% attained high and very high levels, respectively. Merely two (2) individuals, constituting 4%, had very low scores.

The findings suggest that nearly 80% of respondents scored below average (0-11), with no individuals achieving above average (23-30) in the pre-test. Conversely, just 32% of them scored below average, while 12% above the average in the post-test. This indicates an improvement in scores from pre-test to post-test, with means of 9.26 and 13.86, respectively. [9] asserts that children comprehend Mathematics more effectively when permitted to utilize tangible examples. This assertion is supported by the perspectives of [10], which advocate for the presentation of Mathematics in a manner that aligns with learners' cognitive styles and thought processes.

Effectiveness of Normal Curve Slider

The effectiveness of the normal curve slider as a manipulative for normal distribution content is illustrated in Tables 3, 4, and 5. The tables presented the comprehensive and post hoc results of the students' pre- and post-tests in normal distribution, together with the LOTS and HOTS post-tests.

Table 3.

Overall Result in the Significant Difference between the HUMSS Students' Pre and Post - Performances as Classified into LOTS and HOTS

Compared Variables	\bar{x}	df	Mean Dif	F-value	p-value	Interpretation
Pre - Performance	9.07	49	6.97	0.78	0.000*	Significant
Post - Performance	16.04					

* $p < 0.05$, significant at 0.05 level (two-tailed)

Table 3 displays a significant difference between the pre- and post-mean performances of HUMSS students, F-value (49) = 0.78, $p = 0.000$. The null hypothesis, which posits no significant difference between the pre- and post-mean performances of HUMSS students in the context of normal distribution categorized as LOTS and HOTS, is rejected. This indicates that the intervention involving the normal curve slider is effective, since the majority exhibited superior performance in the post-test ($\bar{x} = 16.04$) compared to the pre-test ($\bar{x} = 9.07$). Research by [9] shown that the effective application of manipulatives significantly enhanced students' academic performance in mathematics. Moreover, manipulatives, as instructional resources, are endorsed by mathematics experts to enhance academic performance in mathematics.

Table 4.

Post Hoc Result in the Significant Difference between the HUMSS Students' Pre and Post - Performances as Classified into LOTS and HOTS

Level	Performance	\bar{x}	df	Mean Difference	t-value	p-value	Interpretation
LOTS	Pre	8.88	49	9.34	13.30	0.000*	Significant
	Post	18.22					
HOTS	Pre	9.26	49	4.60	7.34	0.000*	Significant
	Post	13.86					

* $p < 0.05$, significant at 0.05 level (two-tailed)

Table 4 exhibits a significant difference in the pre- and post-performances of HUMSS students under the LOTS, t-value (49) = 13.30, $p = 0.000$. This indicates that the null hypothesis, which claims no significant difference between the HUMSS students' pre- and post-performance levels

of LOTS, is rejected. This indicates that the implemented intervention, utilizing the normal curve slider, is effective, as the majority showed greater results in the post-test ($\bar{x} = 18.22$) compared to the pre-test ($\bar{x} = 8.88$). The findings indicated a significant difference in the pre- and post-performances of HUMSS students under HOTS, $t\text{-value} (49) = 7.34, p = 0.000$. This indicates that the null hypothesis, which asserts no significant difference between the HUMSS students' pre- and post-performance levels of HOTS, is rejected. The findings confirm that the intervention, specifically the use of the normal curve slider, is effective, as the majority showed better results in the post-test ($\bar{x} = 13.86$) compared to the pre-test ($\bar{x} = 9.26$). Manipulatives are tangible educational tools that enable students to grasp abstract concepts by making them concrete. They facilitate the connection between manipulatives and abstract mathematical ideas by providing concrete experiences and ultimately ensure the long-term retention of mathematical skills [11].

Table 5.
Post - Performances of HUMSS Students in LOTS and HOTS

Compared Variables	\bar{x}	df	Mean Dif	t-value	p-value	Interpretation
LOTS Post - Performance	18.22	49	4.36	5.41	0.000*	Significant
HOTS Post - Performance	13.86					

* $p < 0.05$, significant at 0.05 level (two-tailed)

Table 5 demonstrates a significant difference in the post-performances of HUMSS students in LOTS and HOTS, $t\text{-value} (49) = 5.41, p = 0.000$. This suggests the null hypothesis, which posits no significant difference between the post-performances of HUMSS students in LOTS and HOTS, is rejected. The result indicates the respondents exhibited better performance in LOTS compared to HOTS. Jean Piaget's constructivist theory (1952) influences educational curricula by necessitating that educators develop plans that promote students' logical progression (from simple to complex) and conceptual development (improvement of knowledge and skills over time). Educators must emphasize the crucial significance that experiences or relationships with the surrounding environment have in student learning. The role of educators is paramount. Rather of delivering a lecture, educators in this paradigm serve as facilitators, assisting students in their comprehension. Furthermore, the participation of educators in the making of performance assessments and scoring rubrics, along with the evaluation of student performances, affords teachers the opportunity to deliberate on curricular values, potentially enhancing learning by involving students in intrinsically motivating and meaningful activities [12].

Attitude towards the Utilization of Normal Curve Slider

Table 6 illustrates the students' attitudes regarding the use of the normal curve slider. The table includes the overall and specific means together with their respective standard deviations.

Table 6.
Attitude towards the Utilization of Normal Curve Slider

Statement	\bar{x}	s	Description
A. COGNITIVE			
1. I find normal curve slider easy to manipulate.	3.36	0.563	Agree
2. I find the slider unique and attractive.	3.54	0.579	Strongly Agree
3. I can easily understand the computations done by my teacher if the normal curve slider is utilized.	3.42	0.575	Agree
4. I believe that I can easily recall concepts in normal curve with the use of the slider.	3.42	0.538	Agree
5. I find the slider as an effective learning tool in Statistics and Probability.	3.48	0.614	Agree
<i>Overall</i>	3.44	0.574	Agree
B. EMOTIONAL			
6. I appreciate the use of the slider in learning normal distribution competencies.	3.64	0.563	Strongly Agree
7. I enjoy using the slider during the class.	3.48	0.614	Agree
8. I find time just to have hands-on with the slider.	3.16	0.548	Agree
9. I feel excited to learn every competency of normal curve since the slider is integrated.	3.30	0.735	Agree
10. I am motivated to solve problems which involve areas under the normal curve because of the slider.	3.34	0.519	Agree
<i>Overall</i>	3.38	0.596	Agree
C. BEHAVIORAL			
11. I listen attentively to the concepts presented by my teacher using the slider.	3.52	0.646	Strongly Agree
12. I follow immediately the demonstration provided in the uses of the slider.	3.44	0.611	Agree
13. I actively participate in the class discussion if the slider is integrated by the teacher.	3.42	0.538	Agree
14. I practice my learned skill using the slider.	3.38	0.635	Agree
15. I can solve now independently problems involving areas under the normal curve with the aid of the slider.	3.42	0.499	Agree
<i>Overall</i>	3.44	0.586	Agree
Grand	3.42	0.585	Agree

Note:

Range of Means	Description
3.50 - 4.00	Strongly Agree
2.50 - 3.49	Agree
1.50 - 2.49	Disagree
1.00 - 1.49	Strongly Disagree

Table 6 indicates that the majority of respondents had a favorable attitude towards the use of the normal curve slider, as evidenced by a grand mean of 3.42 and a standard deviation of 0.585. A positive attitude is evident across all dimensions: cognitive ($\bar{x}=3.44$), emotional ($\bar{x}=3.38$), and behavioral ($\bar{x}=3.44$). Specifically, the majority express strong agreement with statements 2, 6, and 11, indicating that they perceive the slider as unique and appealing (cognitive level), value its application in understanding normal distribution (emotional level), and engage attentively with the concepts presented by the teacher utilizing the slider (behavioral level). Furthermore, the majority concur with the remaining statements (1, 3, 4, 5, 7, 8, 9, 10, 12, 13, 14, and 15). At the cognitive level, they find the normal curve slider easy to control, comprehend the computations performed by the teacher, believe they can readily recall topics, and regard the slider as an efficient educational tool in Statistics and Probability. Emotionally, they derive pleasure from utilizing the slider during class, allocate time for hands-on engagement, experience enthusiasm in mastering the competencies related to the normal curve, and are driven to tackle difficulties involving locations beneath the normal curve. At the behavioral level,

students promptly adhere to the demonstrated applications, engage actively in class discussions, practice the acquired ability, and are now capable of independently resolving problems related to areas under the normal curve. [11] indicated that manipulatives at the cognitive level facilitate students' integration of knowledge and association with their thoughts, thereby enhancing their comprehension of mathematical concepts. Additionally, they promote communication of students' mathematical thinking and elevate their mathematical ideas to a higher cognitive level. Furthermore, on an emotional level, students elicit pleasure during the learning process by fostering active engagement from both students and teachers, thereby facilitating enduring learning through the establishment of equitable opportunities among students. [13] similarly affirmed in his study that the concepts of early theorists continue to encourage educators to utilize manipulatives. Ultimately, at the behavioral level, the active participation of students in their learning is likely to foster a favorable shift in attitude towards the subject and boost achievement.

CONCLUSION AND RECOMMENDATIONS

The study concludes the normal curve slider is highly effective for studying statistics and probability, especially for normal distribution. The manipulative is particularly beneficial for comprehending lessons on the normal curve at both lower and higher levels of cognitive processing. Additionally, employing manipulatives can augment motivation and facilitate learning, especially at the Senior High School level. Reevaluating one's viewpoint on the contemporary educational system reveals that there are always successful methods of learning in the 21st century. The use of manipulatives in Mathematics instruction is appropriate at all stages of basic education for both learners and educators.

REFERENCES

- [1]. Felder, R. & Brent, R. (2005). Understanding student differences. *Journal of Engineering Education*, 94(1), 57-72. <http://dx.doi.org/10.1002/j.2168-9830.2005.tb00829.x>
- [2]. Corsi, L. (2014). The use of concrete manipulatives in third grade special education and student achievement. https://soar.suny.edu/bitstream/handle/20.500.12648/297/Laura_Corsi_Masters_Project_May2014.pdf?sequence=1&isAllowed=y
- [3]. Furner, J. & Worrell, N. (2017). The importance of using manipulatives in teaching math today. *Transformations*, 3(1). <https://nsuworks.nova.edu/transformations/vol3/iss1/2>
- [4]. Neesam, C. (2018). Are concrete manipulatives effective in improving the mathematics skills of children with mathematics difficulties? <https://www.ucl.ac.uk/educational-psychology/resources/CS1Neesam15-18.pdf>
- [5]. Desoete, A. & Grégoire, J. (2006). Numerical competence in young children and in children with mathematics learning disabilities. *Learning and Individual Differences*, 16(4), 351-367. <https://doi.org/10.1016/j.lindif.2006.12.006>
- [6]. Memnun, D. & Ozbilen, O. (2019). A qualitative research on the difficulties and failures about probability concepts of high school students. *Journal of Educational Issues*, 5(1). <https://files.eric.ed.gov/fulltext/EJ1206642.pdf>
- [7]. Chiesi, F. & Primi, C. (2010). "Learning probability and statistics: Cognitive and non-cognitive factors related to psychology students' achievement. https://iase-web.org/documents/papers/icots8/ICOTS8_7C1_CHIESI.pdf?1402524971
- [8]. Naccache, H. (2012). Factors related to student performance in statistics courses in Lebanon. <https://aquila.usm.edu/dissertations/852/>
- [9]. Vizzi, A. (2016). Teachers' perceptions of manipulatives during middle school math instruction. <https://scholarworks.waldenu.edu/dissertations/2080/>
- [10]. Larbi, E. & Mavis, O. (2016). The use of manipulatives in mathematics education. *Journal of Education and Practice*, 7 (36). <https://files.eric.ed.gov/fulltext/EJ1126428.pdf>
- [11]. Konaş, H. (2016). The effect of manipulatives on mathematics achievement and attitudes of secondary school students. *Journal of Education and Learning*, 5(3). <http://dx.doi.org/10.5539/jel.v5n3p10>
- [12]. Garo, C. (2011). Teaching educational technology: Guidelines in the selection of instructional materials. <http://hcdc-eductech.blogspot.com/2011/07/guidelines-in-selection-of.html>
- [13]. White, K. (2012). The effect of an instructional model utilizing hands-on learning and manipulatives on math

achievement of middle school students in Georgia.

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