Sprin Journal of Arts, Humanities and Social Sciences OPEN ACCESS
Abbreviated Key Title: Spr. J. Arts. Humanit. Soc. Sci. ***ISSN: 2583-2387 (Online)***
Journal homepage: https://sprinpub.com/sjahss *Vol.02(6). June 2023, pp, 11-18*

Spreadsheets Application in Teaching Data Management in Mathematics of the Modern World: Effects on Students' Performance

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DOI: 10.55559/sjahss.v2i06.117 **Received:** 03.05.2023 | **Accepted:** 05.06.2023 | **Published:** 06.06.2023

Electronic reference *(Cite this article):*

Mulle, R. (2023). Spreadsheets Application in Teaching Data Management in Mathematics of the Modern World: Effects on Students' Performance. *Sprin Journal of Arts, Humanities and Social Sciences*, *2*(06), 11–18. https://doi.org/10.55559/sjahss.v2i06.117

ABSTRACT

This study aimed to investigate the effects of spreadsheet application in teaching Data Management in Mathematics of the Modern World on the students' performances among first-year College Students during the Second Semester of School Year 2022-2023. A quasi-experimental research design with the pretest-posttest non-equivalent groups design was employed in the study with the researcher–made questionnaire comprising 40 items test. The statistical methods used to gather data were treated using mean, t-test for independent samples, z-test for correlated samples, and standard deviation. Data were gathered from the 74 first-year college students in Jose Rizal Memorial State University–Main Campus. Results revealed that the pre-test and post-test performance of the students in the control and experimental groups was good. But their post-test performance in the experimental group was excellent. It is concluded that Spreadsheet Application is a very important and effective tool in teaching Data Management in Mathematics of the Modern World to first-year college students. Its application tremendously increases students' performance from the pre-test to the post-test.

Keywords: *data management, Mathematics, spreadsheets application*

Introduction

In response to the rapidly changing world today and with globalization that demands new skills to be developed in the present generation of young students, the Philippines Government has been looking for new solutions and innovations to uplift and improve the quality of the education system and deliver education more effectively. One of the changes made, the Commission of Higher Education (CHED Memorandum no. 59, series of 1996) initiated the general education curriculum revision in replacing the old general education mathematics subjects with *Mathematics of the Modern World* due to the effects of Senior High School as mandated by the RA. 10533 (K-12 Law).

The *Mathematics of the Modern World* is a 3-unit subject that is part of the 36 general education units started in 2018 and implemented in all education curricula (GEC) (Roman & Villanueva, 2019). This subject is not a repetition of topics and concepts learned in high school algebra but rather an exploration of the nature of mathematics and how the world is often

viewed and understood using a mathematical lens (Bautista et al., 2017). This pertains to nature's explorative mathematics of patterns and involves inductive and deductive reasoning. Moreover, the course is expected to become a means by which students are more adept at understanding and dealing with present-day living. These include learning personal financial management, making social options, appreciating the designs related to geometry, learning codes, and doing all of these with limited resources.

Roman and Villanueva (2019) concluded that students had encountered difficulty on the different topics in Mathematics of the Modern World and recommended the utilization of advanced technology. On the contrary, Wentworth and Middleton (2014) also cited that technology appears to have a damaging effect on academic performance. According to Talib et al. (2012), the Grade Point Average (GPA) system best predicts student academic performance. Warner and Meehan (2001) cited Davis (1997) study that spreadsheet applications such as Microsoft Excel is a versatile software that provides immediate access anytime and anywhere. It is low-cost software that can perform the most basic analyses and easily provides a graphical output using its Chart Wizard feature.

The researcher emphasized those active and enthusiastic users of digital communication technologies are prone to sleep deprivation and have lower learning satisfaction, which, in turn, was correlated with poor academic performance. Thus, the researcher is encouraged to conduct this study to determine the effects of spreadsheet application in teaching Data Management in Mathematics of the Modern World on the students' performances among first-year College Students during the Second Semester of School Year 2022-2023.

Theoretical/Conceptual Framework

The researcher utilized three (3) theories, namely: The constructivist theory of Piaget, Engagement Theory of Kearsley and Shneiderman as cited by Drake (2010), Galleto and Refugio (2012), and Cognitive Load Theory (CLT)" cited by Clarke, T. et al. (2005).

Constructivist theory. The theory states that learners do not acquire knowledge and understanding by passively perceiving it within a direct process of knowledge transmission. Rather, they construct new understandings and knowledge through experience and social discourse, integrating new information with what they already know. This theory emphasizes learners be actively involved in their learning, providing the students with a welcoming environment that promotes active engagement that enables them to view their ideas and assist them in restructuring their views based on actual and hands-on experience, teaching the student how to develop their cognition and provide them with a means of self-expression. Exposing students to use the spreadsheet application allows them to discover more, build new knowledge based on their foundations of existing knowledge, and integrate with it (Major et al., 2012). Hence, learning can be enriched, motivating, intellectually satisfying, and enhance students' independent learning.

Engagement Theory. This study also hinged on the “Engagement Theory” of Kearsley and Shneiderman (1998), as cited by Drake (2010), Galleto and Refugio (2012). This theory promotes learning allowing the students to trade points of view through meaningful collaboration and interactive tutorials and enhances creativity among the students in a project-based manner. In principle, engagement could occur without spreadsheet application, but research has revealed that the software program can be used to quickly solve complicated mathematical models (Baker & Sugden, 2003).

A technological tool such as a spreadsheet is believed to be capable of solving problems involving numbers which can be automatically summarized, analyzed by the subject matter, explored, presented data, created mental models, and then transcribed into knowledge bases and even powerful if the data used are repetitive and changes over time (Nanjappa & Grant, 2003). This theory bridges a connection to the present investigation in developing intrinsic motivation in the learner’s mind. The experiment in this study allows the students to connect,

create and contribute through hands-on activities using a Microsoft Excel Spreadsheet mediated by the teacher.

Cognitive Load Theory. This study is also grounded on the "Cognitive Load Theory (CLT)" cited by Clarke, T. et al. (2005), which states that the orderly succession of content should be utilized to promote pedagogy: introduction of the subject from the known to unknown; easy to difficult. A theory that helps the learner in knowledge construction and not in knowledge reproduction. This theory provides a guideline to assist in the presentation of information in a manner that encourages learners to optimize their intellectual performance by showing them what to do and how to do it, allowing them to practice, perform on their own and enhance them to be more confident about their tasks.

According to CSE (2018), when information is complex or new, teachers can reduce the load on students' working memories, or when information is easy for students, teachers can gradually increase the complexity of the lesson. This theory also emphasized some strategies to optimize the load on students' working memories in creating more mental space for learning, such as tailoring lessons according to student's existing knowledge and skill, using worked examples in teaching new content or skills, gradually increasing independent problem-solving as learner become more proficient, cut out inessential information, present all the essential information together, simplify complex information by presenting it both orally and visually, and encourage students to visualize concepts and procedures that they have learned.

Incorporating the use of spreadsheet applications such as Microsoft Excel as a cognitive tool, along with constructivist learning environments and intrinsic motivation, can lead them to a more active and collective engagement during class, such as automating the calculations in a short time, amplifying the examination of multiple graphs and different representations, modifies simulations by controlling the parameters where students can be easily able to make and test conjectures and create an opportunity to let the students practice, understand and experience real life statistics problem by giving them data sets and have them process the full analysis on their own (Chance et al., 2007). This connects the present investigation considering the present study focuses on the student's learning in the subject. Secondly, the present study looks into the effectiveness of using spreadsheet applications to purport performance improvements in Data Management in Mathematics of the Modern World.

Methodology

This research employed a Quasi-Experimental Research Design with the pre-test-post-test non-equivalent groups design utilizing two groups as control and experimental groups. Pre-test was given to both groups before the intervention. The experimental group was exposed to the MS Excel spreadsheet application, while the control group was exposed to the traditional method. After discussing the three (3) topics, students were given the post-test.

The researcher facilitated the control and experimental groups of the study based on their class schedules. The control group met every Monday – Wednesday from 4:00 PM to 5:30 PM, while the experimental group met every Tuesday – Thursday from 4:00 PM to 5:30 PM from April 11, 2023, up to April 25, 2025, at the e-library. This research design is deemed appropriate since the study attempted to discover the effectiveness of spreadsheet application in teaching Data Management in Mathematics of the Modern World on students' performance.

The study's respondents were first-year college students officially enrolled in the subject Mathematics of the Modern of Jose Rizal Memorial State University-Main Campus in Dapitan City during the 2nd Semester of the School Year 2022-2023. The groups consist of a total of 74 students utilized as the subject of the study through purposive sampling.

The process that was involved in the experiment is present in Figure 2. As shown, the control and experimental groups took the pre-test (X1 and Y1) prior to the treatment. After the pre-test, the students in the control group were taught using the traditional method while the

experimental group was taught using the spreadsheet application. After the treatment, both groups were given a post-test (X2 and Y2).

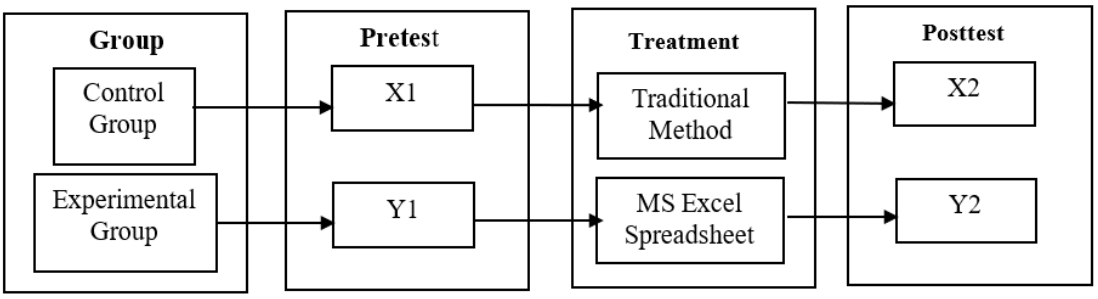

Figure 1. The Research Process

In this study, a 40-item researcher-made test was utilized by the researcher to gather all the data needed to answer the specific problems in the study. A multiple-choice test was constructed with the help of books and other teaching kits. The test items were crafted based on the topics treated in the experiment: Data Presentation and Interpretation, Univariate Statistics, and Bivariate Statistics. This instrument was designed based on Bloom's Taxonomy.

The draft of the test instruments consisting of 50 items was referred to the researchers' adviser to pass judgment on the instrument's content, appropriateness, and suitability. The researcher crafted the 50-item test to meet the targeted 40 items in the final instrument. After incorporating the adviser's comments and suggestions, the corrected draft was presented to a panel of experts, including the Statistician and the adviser, for content validation. The recommendation of the validators is considered in the final copy of the test. Once validated, the copies of the questionnaires will be then distributed personally by the researcher to the respondents.

Reliability tests and item analysis were administered to the 69 College of Engineering Students officially enrolled in JRMSU-Main Campus. The respondents who had already taken the topic covered in this study were used as the pilot samples to test each item's difficulty level, discriminatory index, and the reliability of the whole instrument. Item analysis was performed using the MS Excel spreadsheet. In conducting the item analysis, all scored test papers were first arranged from highest to lowest score. The first 27 students scored the highest as the Upper Group (UG), and 27 scored the lowest as the Lower Group (LG).

Looking at the item analysis results, 14 items were retained, 28 items were for revisions, and Eight (8) items were rejected. Out of 50-item questionnaires, 13 very difficult items, 12 difficult items, and 25 moderately difficult items. The analysis also revealed that 18 items were very good, five (5) items were reasonably good items, eight (8) items were moderate items, 15 items were fair, and four (4) were poor (Hopkins & Antes, 1990). The result of the item analysis was instrumental for the researcher to retain, revise and reject the test items. Thus, the original 50-item test was reduced to 40 items to cope with the target of a 40-item test. The reliability coefficient of the test using the Kuder Richardson Formula 20 is 0.76, which denotes a high relationship and acceptable internal consistency. This means that the whole test was both valid and reliable.

Results and Discussion

Pre-test Performance in the Control and Experimental Groups. The data presented in Table 1 is the results of the pre-test administered to the control and experimental groups. The pre-test performance of the students was obtained before the groups were exposed to the assigned interventions.

Table 1
Pretest Performance of the Students in the Control Group and Experimental Group

Areas	No. of Items	H.M	Control Group			Experimental Group		
			AM	Description	z-value	AM	Description	z-value
Data Presentation and Interpretation	13	9.75	6.5	Good	24.00	7.8	Good	32.52
Univariate	22	16.5	11.0	Good	23.79	13.2	Good	28.39
Bivariate	5	3.75	1.5	Fair	19.32	3.0	Good	23.12
Total	40	30.0	19	Good	67.11	24	Good	84.03

Table 1 presents the pre-test performance of students in the control group. As presented in the table, there were 13 items in the test questionnaire in data presentation and interpretation. The hypothetical mean of 9.75 is equivalent to 75% of the total number of items in the area treated. The actual mean was 6.5, described as "Good," with a z-value of 24.00. In the area of univariate, 22 items are being considered during the pre-test performance, and a hypothetical mean of 16.5 while the actual mean of 11.0 is described as good. The z-value obtained was 23.79. In the case of the bivariate, it has five total items; the hypothetical mean was 3.75, and the actual mean of 1.5. This tells that the student's performance in bivariate fell in the "Fair" category with a z-value of 19.34.

The hypothetical mean was 30.5 from the total number of items, 40. The actual mean was 19 falls in the category with a z-value of 67.11. It is safe to say that the student's performance along the pre-test in a control group did not surpass the hypothetical mean of 30, which is only 75% of the total number of items. Therefore, the lesson's performance depends on the teacher's discussion on the subject taught, and schema on the topic shall play a very salient role in the students' achievements.

Also, in Table 1 reflects the pre-test performance of students in the experimental group. The actual mean of 7.8, described as good. The z-value of 32.52 signifies that the students are good at interpreting data, as presented in the table or histogram. In the univariate case, twenty-two (22) items were included in the questionnaire understudy with 75% or the hypothetical mean of 16.5, and the actual mean of 13.2 falls in the “Good” category. The z-value was 28.39, reflecting that the student’s ability in the univariate activities was only limited to good. Students are good to be exposed to the said topics to improve their knowledge of the subject matter further. Following the same vein, the bivariate with five items only got the hypothetical mean of 3.75 and the actual mean of 3.0, confirming the “Good” performance of the students. The z-value of 23.12 tells that the student strived to be good at the topic. In general, the forty (40) items representing the totality of this subject matter that the hypothetical mean of 30 and 24 as actual mean described as “Good.” The finding was supported by the total z-value of 84.03, which implies that the student’s performance was good on the three subject matters included in the study.

Aguilar-Cruz, et al., (2023) refuted the finding of the present finding, where she revealed that the pre-test performance of the experimental group in purposive communication was found to be “Fair.” However, Cabalida (2023) corroborated that the experimental group in her study confirmed the findings of the present investigation. Further, according to the author, the students in Filipino topics received lower results in the actual mean because they lacked sufficient subject understanding. The results were anticipated to match those of the control group on the pre-test.

Post-test Performance in the Control and Experimental Groups. Table 2 presents the post-test performance of the control group. As presented in the table, out of 13 items in the data presentation and interpretation, the hypothetical mean was 9.75, and the actual mean was 7.8, described as a "Good" performance. The z-test value was 32.01. This tells that there was little improvement in student's performance in the subject area being studied compared to the

pre-test performance. Along the lines of univariate, twenty-two (22) items were included in the test. The hypothetical mean was set at 75% and thus obtained 16.5, and the actual mean was 13.2. It falls in the "Good" category, and the z-value was 48.00. The results implied that the students showed slight improvement during the post-test. There were only five items included in the post-test in the bivariate area. The hypothetical mean was 3.75, and the actual mean was 3.0. This performance was described as "Good." The z-value was 28.01displays that the students had shown slight improvement against the pre-test.

In totality, the hypothetical mean was 30, set at 75% of the total items of 40. The mean was 24, described as good, and the total z-value was 108.02. This shows that the control group displayed good achievements in three areas of mathematics as the students were taught using ordinary strategies in teaching mathematics. The findings above were refuted by the findings of Ageas (2023) when he revealed that the pre-test performance of students in mathematics did not do better using ordinary teaching strategies.

Table 2
Post-test Performance of the Students in the Control Group and Experimental Group

Areas	No. of Items	H.M	Control Group			Experimental Group		
			AM	Description	z-value	AM	Description	z-value
Data Presentation and Interpretation	13	9.75	7.8	Good	32.01	11.70	Excellent	38.90
Univariate	22	16.5	13.2	Good	48.00	20.90	Excellent	43.77
Bivariate	5	3.75	3.0	Good	28.01	4.75	Excellent	25.52
Total	40	30.0	24	Good	108.02	36.35	Excellent	108.19

Further, it can be seen in the above table that the area of data presentation and interpretation bears the hypothetical mean of 9.75 from the original number of items of 13, and the actual mean was 11.17, described as “Excellent” and the z-value of 38.90. These findings showed that the experimental group exerted efforts to achieve such excellent performance. The students further showed that they had learned much in the spreadsheet application in bearing data interpretation from the tabulated data.

In the case of univariate, it was seen in the biggest improvement of the experimental group when taught using spreadsheet application in teaching mathematics. This was supported by the actual mean of 20.90, which exceeded very much compared to the hypothetical mean of 16.50, claimed as excellent. The z-value was 43.77, showing that teaching univariate using a spreadsheet application can easily be learned by the students.

Similarly, bivariate bears five items with a hypothetical mean of 3.75, and the actual mean was 4.75, described as “Excellent.” The z-value was 75.52. There were no reasons for getting the lowest scores when students were exposed to computed-aided applications in teaching. The spreadsheet application aided very well in the excellent performance of the students.

The hypothetical mean of 30 was generally surpassed by the actual mean of 36.35, again sketched up as “Excellent.” The total z-value was 108.1 9. The findings depicted that the spreadsheet application in teaching mathematics portrayed excellent performance in teaching the subject areas treated in the study. Cabalida (2023) supported that present investigation when she revealed that the experimental group soared higher in post-test examination than the pre-test. Teaching strategies improve the achievement of the students.

Table 3
Test Difference on the Mean Gain Scores Between the Control and Experimental Group.

Groups	Mean	SD	Computed t-value	C.V. (t)
Control	10.09	4.92	4.026*	1.66
Experimental	17.54	5.20		

*Legend: ** - Significant, ns – not significant, α – 0.05

Table 3 shows significant differences in the mean gain scores between the control and experimental groups. The control group got a mean of 10.09 with a standard deviation of 4.92, while the experimental group obtained a mean of 17.54 with a standard deviation 5.20. The computed t-value was 4.026 outmatched the critical value of 1.66. Therefore, there was a significant difference between the mean gain of the control and experimental groups. The mean gain implied that spreadsheet application as a strategy outstripped ordinary strategies. Thus, the mean gain was evidenced in favor of the experimental group.

Ageas (2023) posited that mean gain was also evident in his study using Man's approach in teaching mathematics. Moreover, Cabalida (2023) supported the findings of the present investigation when she revealed that mean gain was observed in the way of social media in the teaching and learning process.

Conclusion and Recommendation

The researcher concludes that Spreadsheet Application is a very important and effective tool in teaching first-year college students Data Management in Mathematics of the Modern World. Its application has significantly increased the student's performance from the pre-test to the post-test. It is recommended that the top management in the University may allocate a budget for infrastructure to provide adequate computer laboratories. The Program Heads may design training for mathematics teachers by utilizing the MS Excel spreadsheet application should also be appropriated. The researcher encourages teachers to explore the use of spreadsheets in teaching Data Management in the Mathematics of the Modern World, which could augment students' performance. Spreadsheets application should be adapted in the classroom instruction for Data Management to ensure variety and efficiency in teaching the subject. Teaching in any subject should be fun and exciting, and lessons should not stick with the traditional "chalk and talk" method but must be introduced in varied ways. Moreover, the students may utilize and apply MS Excel spreadsheet application to learn Data Management in Mathematics of the Modern World to enhance and ensure higher performance.

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