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Effectiveness of Excel Software Integration in Teaching and Learning Statistics on Students' Performance in Selected Kicukiro District Upper Secondary Schools in Rwanda

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***Abstract**: Some students performed better in other areas of mathematics considered in the examination but failed in statistics. As that, teaching statistics should differ from teaching other subjects of mathematics (Dushimimana & Uworwabayeho, 2021). The main purpose of this paper is to find the effect of Excel software integration in teaching and learning statistics on students' performance in selected upper secondary school. The study was conducted on students of Kicukiro district public secondary school A, in Kigali City in Rwanda. 12 students were purposively selected. Experimental and control group were formed, and they used excel software and scientific calculators respectively. Administrated test was given, before and after intervention. One way ANOVA and descriptive statistics were used in SPSS software during data analysis. A significant advantage for the experimental group over the control group as a positive effect of excel software integration in teaching and learning statistics was detected. The study recommends giving computers to teachers teaching core mathematics, to train teachers on how to use statistical software like excel, to increase computer lab in secondary schools and to facilitate students to use excel software in statistics.*

***Keywords**: Excel software integration, Effectiveness of Excel software Integration, statistical software, teaching and learning statistics, students' performance*

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1. Introduction

The integration of ICTs in the teaching and learning curriculum is a clear goal for initiatives to improve education in schools. ICT integration can be defined as an integral or mediated tool used to complete specific teaching or learning activities in order to meet specific instructional objectives. However, most schools, look for specialized educational software and hardware to achieve this integration. ICTs are a collection of educational technological tools and resources used to communicate, create, distribute, store, and manage information. Example of these educational technological tools are computers, Internet, broadcasting technologies. Recent developments of educational technological tools, offer to teachers an additional method for teaching statistics content and practice (Nchimunya, 2016).

Nchimunya's (2016) study, again declared that, critics of using technology in teaching statistics indicate that

students must spend time learning the package and are therefore not concentrated on learning statistics. Using a spreadsheet such as Excel can overcome some of these difficulties by constructing powerful demonstrations of statistical ideas for what is intended to be taught.
Additionally, students should study statistics in a way that allows them to apply it in real life. Learning statistics entails learning to communicate using statistical language, solving statistical problems, drawing conclusions, and supporting those conclusions by explaining the reasoning behind them. For teachers to teach statistics requires teachers to have mathematical skills as well statistical thinking and reasoning (Umugiraneza, 2018).

When the teacher is teaching statistics, the theories become more real when they are explained with the help of software. Sometimes in the explanation of the theory students are less understanding but after practice, they just understand what was explained before. During Statistics, there are a lot of things that cannot be explained only by theory. For example, to explain area under the normal curve. The theories taught without practice have a greater chance of being forgotten than learning with practice (Akbar & Supratman, 2019). Since 2016, the government of Rwanda initiated a national program called Smart classroom. This initiative aimed to equip Rwandan schools with an IT infrastructure that facilitated the digitization of learning and teaching processes at all levels of education (primary, secondary, higher education as well as vocational training centers) and for all subjects (Digital Africa,2021).Furthermore, it has been shown that the effective improvement in ICT use, can lead to improvement of teacher's performance at higher level in the secondary school teaching and learning process. This means that teachers who want to improve their teaching practices should integrate ICT into their daily activities on a regular basis. (Nsekandizi; Karangwa & Adala, 2020). Despite this, students performed poorly in statistics and probability question and in mathematics in general (Dushimimana & Uworwabayeho, 2021). Some students performed better in other areas of mathematics considered in the examination but failed in statistics and probability questions and vice-versa. The teaching of statistics should differ from teaching other area of mathematics. In mathematics, graphs are often used to show the same relationship while in statistics they are used to identify different aspects of the same data. It is the responsibility for mathematics teachers to understand the different approaches of teaching statistics by making clear to the students that reasoning needed for interpretation in statistics. It is important that in-service teachers receive adequate training in the teaching of statistics (Dushimimana & Uworwabayeho, 2021).

After ICT integration in teaching and learning in secondary schools of Rwanda, where there was poor performance of students in statistics when they were taught in traditional methods or using scientific calculators, the purpose of this research is to determine the effect of excel software integration in teaching and learning statistics on students' performance.
Excel software or other statistical software like R or SPSS are not used in teaching and learning statistics in secondary schools of Rwanda, where there is poor performance in statistics, when students use calculators. As that a results of this, this study was undertaken to find the effect of excel software integration in teaching and learning statistics on student's performance in selected Kicukiro district secondary school.

2. Literature Review

Students' performance in statistics using Excel software or scientific calculators in teaching and learning

Performance is the rate at which educational objectives are met by students in the school system. As a result, academic performance can be viewed as the extent to which students achieve educational goals and objectives. The performance of students can be used to assess the effectiveness of the school system (Owan , Nwannunu , & Madukwe , 2018). Excel software as a tool used to teach statistics, is a software which is flexible to provide numerous applications ranging from data management to statistical analysis. Excel software helps in basic statistical analysis, such as t-tests, F-tests, correlation, and regression. Furthermore, Excel can be used to teach statistics in a variety of ways, such as demonstrating the statistical power of an experiment, exploring experimental variability, calculating probabilities, and so on. More importantly than the variety of methods it is used, Excel software can be used in teaching statistics and is the easiest and most accessible software. (Serhat, 2016)

Statistics courses contain procedures of collecting, representing, summarizing, analyzing, and drawing conclusions from the data. The procedures require complex calculations using some formulas. The calculations are more complex when the number of the data, the types of analysis, and the studied variables are increased. This complexity causes students to have some difficulties in learning and understanding the courses if statistics is studied using pen and calculator (Pasini, 2020). For example, students may subtract each of the data by its average to determine residuals in the analysis of variance. If there is an error at a particular step, students must repeat the process from the beginning to the end. Statistical software such as Minitab or SPSS are used to overcome these difficulties.

Using the software has the advantages to help students to understand the characteristics of the data and the results of analyzed data immediately and comprehensively. For example, students could determine data deviated too far

from a mathematical model of regression analysis and make decision about the data (Pasini, 2020).

Furthermore, Excel software used by statistics educators is useful when teaching, measures of dispersion (for example, range, quartiles), regression and correlation. Sometimes, students are perplexed about how these statistics differ from one another. One common misunderstanding among secondary students occurs when they learn that the correlation can be described as the strength of linear association or when they calculate the median, which is equal to the second quartile. According to some students, the strength of linear association appears to describe a regression slope because a steep slope may reflect a strong impact of the independent variable on the dependent variable, whereas a flat slope may reflect a weak impact of the independent variable on the dependent variable. Excel software may assist students in better understanding measures of dispersion, and how correlation and regression results show different types of association strengths, and how teachers frequently use Excel software to assist students in understanding statistics (Lilly & Miller, 2021).

However, the use of the scientific calculator is needed in the topics that required its use and this according to Examinations Council of Zambia. Those topics are trigonometry, sequences, Geometric Geometry (distance between two points), and statistics for calculation of standard deviation (Mashekwa , 2021)**.** Additionally, the study conducted on the effects of the availability of ICT equipment, the role of computer-aided instructions, such as the use of specific software programs to teach and promote learning, are found to have no statistically significant effects on student performance (Gui, 2017). Again, the findings of those studies showed that the use of ICT is not more effective than traditional teaching methods. Another reason for low ICT effects in schools could be the difficulty of integrating ICT into educational practices. The availability of ICT-related educational devices such as computers, tablets, software, or educational programs is insufficient to improve student performance; rather, it is the actual practice that teachers make for these devices, combined with the teachers' level of ICT skills (Gui, 2017). In addition to that, to encourage students to learn mathematics using scientific calculators, particularly in Solid Geometry and Statistics topics, may help students with low performance to enhance their understanding (Fatimah, Kamarudin, Mas, & Nurazidawati, 2021). Moreover, using a scientific calculator also has a positive effect on students' ability to solve statistical problems. Students are better statistical problem solvers when computation tools are used in class. Scientific calculator integration in teaching and learning approach enables students to solve mathematics problems efficiently (Fatimah et al, 2021). Integrating technological tools in an integrative teaching and learning approach provided students with a better learning process (Fatimah et al, 2021).

3. Methodology

3.1. Research design

Research designs are acts for gathering information in qualitative, quantitative, and mixed methods approaches that provide specific guidance for procedures in a research study (Creswell, 2018). This study used Experimental Research Design

3.2. Population

A population refers to a group of all individuals who possess characteristics under investigation (Njiku, 2021). This study involved 12 students from school A, of senior four that studies core mathematics with teacher who has got a computer given by Rwanda Basic Education Board. The selected public secondary school is in Kicukiro district, in Kigali City of Rwanda.

3.3. Sampling Procedure

A sample is a specific group of the population under investigation in which you collect data (Njiku, 2021). Non-probability sampling was used to create the groups of the study by dividing students of senior four into two groups: one experimental and another control. To obtain control and experimental group, a quasi-experimental design was used, where the teacher as someone who knows his students, created two groups based on their performance in mathematics such that, those two groups contain students who are weak and strong in mathematics. And finally, to know the group which will be control or experimental, a random way was used by writing control and experimental on two different small pieces of paper and called two students from the created two groups, and each choose one. Student who chose experimental means that, his group becomes experimental group and student who chose control, his group becomes control group. Both groups did the same test in pre and post-test. The post test was done three weeks after the pretest that is after teaching statistics using excel software in experimental group.

Because excel software is not commonly used in teaching and learning in Rwandan secondary schools, the researcher met with the teachers first, and trained them on how to use it in teaching and learning statistics. Then they also taught their students. Then afterwards they were given pretest. After data collection, the researcher went back to school and took all students in the computer laboratory and studied how excel software is used in their statistics course.

3.4. Validity and reliability of the study

3.4.1. Validity

The accuracy with which a method measures what it is intended to measure is referred to as its validity. If research has high validity, it produces results that correspond to real physical or social properties, characteristics, and variations (Kubai, 2019).

To validate the test, a copy of a test was given to supervisor, and another was sent to the teacher at a public secondary school P of Kicukiro district who has senior four, studying core mathematics, and then the items that were irrelevant were removed.

3.4.2. Reliability

The consistency of test scores across different occasions of testing, different editions of the test, or different raters scoring the test taker's responses is defined as their reliability (Livingstone, 2018).
To determine the reliability of the test, a pilot study was conducted in school P of Kicukiro district.

3.5. Data analysis methods

The process of systematically applying statistical and/or logical techniques to describe and illustrate, condense, recapitulate, and evaluate data is referred to as data analysis (Savenye & Robinson, 2004).
After data collection, data analysis was done by comparing mean scores obtained in pre-test and post-test given to both groups of participants. Students' scores from the pre and the posttests were collected and then analyzed via SPSS package, using descriptive statistics (mean, standard deviation, and standard error) and inferential statistics (One- way ANOVA). Analysis of these scores aimed to:

- Present the initial performance in statistics of students by collecting their scores on the pretest.
- Compare posttest results of the experimental group to posttest results of the control group to investigate the effect of Excel software integration in teaching and learning statistics on students' performance.

4. Results and Discussion

The study aimed to find the effect of excel software integration in teaching and learning statistics on students' performance.
Testing of hypothesis: Students' performance in statistics using Excel software is the same as using scientific calculator (= traditional method)

4.1. Results

4.1.1. Results of Pretest

1. School A

Table 1: Descriptive statistics

Groups	N	Sum	0Mean	Std. Deviation	Variance	Skewness	Kurtosis
G1	6	69.0	11.50	0.71	0.50	0.00	-.333
G2	6	81.0	13.50	0.55	0.30	0.00	-3.333

G1: Control group; G2: Experimental group; N: Number of students

Table 1 shows the descriptive statistics of the experimental group versus the control group in terms of student's performance in the pretest. The experimental group has a higher mean score (Mena=13.5) than the control group (Mean = 11.5). In addition to that, the distribution of scores around the mean is slightly higher in the control group (Std. Deviation = 0.71) compared with the experimental group (Std. Deviation = 0.55).

Table 2: One Way ANOVA

	Sum of Squares	Degree of freedom	Mean Square	F
Between Groups	12	1	12	30
Within Groups	4	10	0.4	
Total	16	11		

We will reject Rho, if $F_{observed} > F_{a-1,\ N-a,\ alpha,}$ *where* $F_{observed} = 30$, *and* $F_{1,\ 10,\ 0.95} = 4.96$
We will reject Ho, meaning that the level of learner's performance in statistics using Excel software is not the same as using traditional method. When excel software is used the students perform better than using traditional method.

4.1.2. Results of Post test

Table 3: Descriptive statistics

Groups	N	Sum	Mean	Std. Deviation	Variance	Skewness	Kurtosis
G1	6	81.0	15	0.89	0.80	0.00	-1.82
G2	6	69.0	17.67	0.82	0.67	0.86	-0.30

G1: Control group; G2: Experimental Control; N: Number of students

Table 3 stands for the descriptive statistics that compare the experimental group to the control group in terms of their performance in the posttest. The experimental group has a higher mean score (Mean = 17.67) than the control group (Mean= 15). In both control and experimental group, the distribution of scores around the mean is less dispersed and almost equal. The control group (Std = 0.89) and the experimental group (Std = 0.82).

Table 4: One Way ANOVA

	Sum of Squares	Degree of freedom	Mean Square	F
Between Groups	21.33	1	21.33	29.22
Within Groups	7.33	10	0.73	
Total	28.66	11		

Results from a one- way ANOVA presented in table 4 show that the difference between the mean score of the experimental group and that of the control group is statistically significant, ($F_{observed} = 29.22$ and $F_{1,10,0.95} = 4.96$) which means that the level of learner's performance in statistics using Excel software is not the same as using traditional method. When excel software is used the students perform better than using traditional method.

4.2. Discussion

4.2.1. Initial performance of students by collecting their scores in the pretest

The data presented above were based on the students' performance of visited school A. Student were given an administrated test twice: a pre-test and a post-test after the implementation of the intervention.

Results from the pre-test showed that there was a statistically significant difference between the performance of the experimental group and the control group in terms of the mean score.

Control group (Mean = 11.5) and experimental group (Mean = 13.5) which shows academic performance (Owan , Nwannunu , & Madukwe , 2018).

This means that before the intervention, both groups were not homogenous in terms of used method to solve a given exercise in statistics. In other words, this shows the efficiency and influence of excel software in studying statistics as a tool that helps students to understand the content (Mishra & Koehler, 2006) and the way students interact with computers, their attitude towards excel software, their ability and time they use to do a given exercise, because students of control group used 40 minutes whereas experimental group used 20 minutes (Pasini, 2020).

4.2.2. Posttest results of experimental and control group

Data related to the post-test, which took place after three weeks of studying test content, results of control and experimental group were presented. Most of the test content was studied in previous years, only the variance and the standard deviation were new in senior four. The comparison between the experimental and the control groups' performances in post-test, showed that the experimental group achieved a higher mean score than the control group. A one- way analysis of variance analysis and descriptive statistics were used. It can be depicted from these results that excel software integration had a positive effect on students' performance in statistics (Mishra & Koehler, 2006), specifically in the topic of measures of central tendency and of dispersion (Lilly & Miller, 2021; Pasini(2020); Nchimunya (2016)). This positive effect is based on the motivation and attitude of students when using excel software (Ailton, Zamora, Lucas, & Thiago, 2018).

Serhat(2016), said that one might prefer to call excel software a sustainable software in teaching statistics to enhance the understanding of important ideas in statistics and to develop statistical thinking. This means that excel software is a tool that helps learners to understand, what is taught in statistics. In brief, results of this study showed that the students' performance in statistics, is better when they use excel software than using traditional methods. But this is not true according to Gui',(2017) study where ICT use is not more effective than traditional teaching methods.

5. Conclusion and Recommendations

5.1. Conclusion

This research has demonstrated that Excel software, can be used as a tool to teach subjects like statistics in secondary schools which have combination with core mathematics. The use of Excel software in the delivery of subjects like statistics enhances the understanding of such subjects. Excel software has an advantage over other statistical software, because is widely available and relatively easy to use. Excel software can be used to teach basic statistics in secondary schools and finally it has a positive effect on student performance in statistics.

Teachers should also take personal initiatives to make use of the available resources for the successful integration of excel software in teaching and learning statistics. Collaboration with teachers worldwide will help them to gain ideas about innovative teaching methods and web-based learning techniques to integrate ICT effectively in their way they teach. Schools may facilitate teachers and students to use excel software during statistics as a tool which helps learners to understand the theory taught and consequently students perform well.

5.2. Recommendations

Many studies (for example: Serhat(2016), (Pasini (2020)) have proved the effectiveness of excel software integration in teaching and learning statistics. One of the main contents of mathematics of senior four with core mathematics in which excel software integration plays an effective role is statistics. Integration of technology in teaching and learning allows students to understand what was taught (Mishra & Koehler, 2006). Likewise excel sofware affects students performance wheh it is used.
In the light of those facts, the following recommendations may be put in place:

1. To distribute computers to all teachers especially to teachers teaching core mathematics
2. To train teachers on how to use statistical software like excel
3. To increase computer lab at secondary schools
4. To facilitate students to use excel software in statistical exercises
5. We finally recommend, the use of excel software in teaching and learning statistics in secondary schools especially in senior four, five and six of other districts of Rwanda, and in universities for future research.

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