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Comparison of Chemistry Test Performances between Learners Studying in Resourced and Under Resourced Schools

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ABSTRACT
The purpose of this paper is to compare chemistry test performances between learners studying in resourced and under sourced schools. This has made many South Africans sensitive towards getting a better education for the upcoming generation. Common perception amongst the community is that private schools provide a better education due to their use of superior learning teaching support materials. Sending children to private schools imposing huge financial burden on parents and making their life more difficult at this time of global economic situation. This perception, which creates a center of belief that, the modern kind of LTSM can only provide a better education', raises doubts. The schools were chosen that one was using modern LTSM and the other was using traditional chalkboard to carry on their routine learning activities. A correlational, experimental method of quantitative data analysis was adopted for this study. Learners' performances from two different schools were empirically analyzed by using the data from a formal test conducted by the Department of Basic Education, Mpumalanga Government. The study revealed that there were no significant differences in their performances when comparing the performances of learners between two secondary schools in a chemistry test. Even though there was a difference in the availability of technology-based LTSM in those two schools, the study concludes that the use of modern LTSM is not a necessary pre-condition for improving quality of chemistry education in particular and science education in general.

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Introduction

Science learners become independent, positive, and active in their own learning in schools where quality learning and teaching prevail. To achieve educational quality, the selection and use of LTSM must provide opportunities for learners to grasp the relevant knowledge and skills outlined in the science curriculum. Instructional materials are important because they assist teachers and learners in avoiding an overemphasis on recitation and rote learning, which can easily dominate a lesson (Milligan et al., 2018). Resource materials provide learners hands-on experiences which help them develop skills and conceptual understanding in addition to work in a variety of ways.

Success of a high school student is considered when a student completes the school leaving examination at a certain predetermined level. In South Africa this school leaving examination called as Senior Certificate Examination (SCE) which was first introduced in 2008 as a part of the high school graduate program after year twelve of formal schooling (Nel & Kistner, 2009). The SCE is currently known as National Senior Certificate Examination (NSCE). Learners complete a three-year learning cycle and attend grade twelve class before having NSCE. The existing high school system in South Africa demands an optimum achievement at grade twelve for the students to be able to continue their study in specialized degree courses (Fridie, 2016).

Concern of parents encourages them to choose one school over the other available schools which is explained under the school choice theory (Friedman, 1962). South African parents have three different choices for sending their kids to high schools. No fee public schools having restricted infrastructural facilities, previously called model C schools having a good amount of infrastructural facilities for an annual fees and local area private schools with different types of available LTSM with an upgraded fee. Gaps between public schools and private schools create the basis for parents' school choice decisions, and many parents decide to send their children to private schools despite their higher costs to study sciences (Pesando et al., 2018). Similar parental behavior to send their children to private or Model C schools to study physical science because of better resources was also observed by Maile (2004). Most probably strengthen the perception developed by Pesando et al., 2018. At initial stage of schooling, parents send their children to local no-fee school to study up to grade nine. If a child is found to perform well in physical science at these levels, then they shift their children either to an old model C school or a nearby private school depending on their ability to absorb the financial consequences. This parental action goes against the perception created in earlier sentence that says private schools provide a better education in teaching and learning of science. Students already performing well, in public schools having poor infrastructure that will perform well wherever they are taken to continue their studies. An analysis of the present South African school system indicated indirect presence of salient features from Friedman's Theory (Friedman, 1962). Public schools are funded by the South African government, based on the number of learners enrolled in a specific public school in a given year. In the case of Friedman's voucher system learners are given vouchers prior to their school admission and students having full freedom to choose their school and hand over the vouchers to the school (Arveseth, 2014). According to Friedman's theory, learners have a clear choice of freedom for the school they want to study (Arveseth, 2014). In South Africa, private schools are also provided subsidies based on certain terms and conditions and private schools are needed to apply for it which can be considered as an extension of Friedman's theory. Friedman believed that the overall level of quality would increase, as parents selected schools, which met their quality preferences between a private and a public school (Arveseth, 2014). Friedman's theory suggests "Deregulation, Competition, and Parental Demand" as the factors behind school choice (Friedman, 1962). Even though school choice by parents is a complicated process and influenced by both rational choice theory and behavioral choice theory (Krull, 2016), the moto behind school selection still remains the quality education of children. It was also reported that affluent parents are more active in school choice for their children and one of the criteria for school choice is academic rigor (Erickson, 2017). It is suggested that community members having economical resources to join a paid school enjoy better opportunity to receive quality education (Reddy, 2006).

Performance and School Infrastructure

It is claimed that information and computer technology (ICT) based teaching-learning programs are pivotal and effective in attaining better teaching-learning outcomes (Ghavifekr & Rosdy, 2015). Severe shortage was observed in ICT based LTSM in rural schools of South Africa. Private schools have more physical resources which assure standards (Pesando et al., 2018). Government conducted township schools, are inferior and underperforming (Maile, 2004). There is a strong believe which can be phrased as the lack of quality educational resources hinders learners' learning (Savasci & Tomul, 2013). Scholars also reported that socioeconomic factors remain at the forefront in contributing to students' performance (Hanushek & Luque, 2003). If the abundance of resources (LTSM) and use of technology is the only major responsible factor for better teaching-learning outcomes, then it stood to reason that the children from poor communities will never enjoy the privilege of education in terms of their success by performing better at NSCE.

Factors Behind Quality School Education

There are evidential prove that crowded classroom, lack of educational software, lack of internet access for learning and lack of teaching materials had the least impact on teaching and learning outcomes (Savasci & Tomul, 2013). It is also reported that in spite of several barriers attitude of learners play a vital role in chemistry teaching-learning outcomes (Chowdhury et. al. 2020; Muhammed, 2021; Onanuga et. al. 2021; Akkus and Doymus, 2022; Krakas, 2022). Even though policy documents emphasize that text books and LTSM play an important role in improving learning outcomes (UNESCO 2016), researchers indicated that the use of LTSM sometime has a limited impact on learners (Milligan et. al. 2018). It is reported that parental perception of better education makes them to prefer private schools across Africa and India (Zuilkowski et al., 2017). At the ground; observation made by authors of this study found that private schools in South Africa and India do provide multiple and advanced LTSM for their students while compared to their government counterpart. In such cases, learning outcomes for private schools should be better than their government counterpart. This claim is declined through a study which analyze public and private schools of different states of India (Kingdon, 2017). The study also raised concern about the cost of private schooling when compared to its outcomes. In this study, availability of advanced LTSM on learning outcomes was focused instead of separating schools in terms of private or public schools.

It is also observed that only 44% of students passed in Physical Science from Mpumalanga province in the year 2017 of which only 29.7% obtained a Bachelor eligibility level (Chowdhury et al., 2018). This implies, only 13 students out of every 100 students who wrote NSCE were eligible for studies at university level. Physical science is a combination of two different subjects. They are physics and chemistry. Many of the undergraduate science courses include chemistry contents. They are agricultural science, food and technology-related studies, medical and biochemical studies, different engineering studies etc. It has been agreed and expressed by many researchers that chemistry is an important subject amongst all science subjects. Also, chemistry is a central science subject for all science-related courses. Authors of this study and many others consider chemistry as one of the important science subjects (Gabel, 1999; Ejidike and Oyelana, 2015; Njoku and Eze-odurukwe, 2015). This information convinced the authors of this study to find the impact of LTSM on chemistry teaching-learning outcomes. The study was planned to understand impact of resources on chemistry teaching-learning outcomes when methodology adopted to teach were same for two different group of learners studying in same grade. That is grade eleven.

A Research question for the study framed as; "Does learners from a resourced school perform better than the learners from an under-resourced school in a chemistry test?"

Following null hypothesis was proposed for the study: "There should be a statistically significant difference in performances for learners coming from two different schools labelled as resourced schools (A) and under-resourced school (B)."

Aim of the Study

The aim of this research study was to compare the chemistry teaching-learning outcomes between grade eleven students of two schools where one school had enough modern LTSM and the other school had minimal LTSM.

Method

Principals of local private and model C schools were approached for permission prior to the beginning of the study. In this study, a correlational-experimental method was adopted to empirically measure the performances of students in chemistry from two different types of schools. This study used quantitative data analysis using MS office tools. One important aspect of this study was to establish the logic behind the selection of the subject to measure learning outcomes of students. The subject was selected on the basis of its importance in the field of science education and its difficulty level.

Focus of the Study

This study focused on studying the impact of resources available as LTSM on the outcomes of chemistry teaching-learning activities while teachers were using a traditional method (Ghavifekr & Rosdy; 2015) to teach in classrooms. Academic outcomes of school students are measured from their academic result which is not dependent on a single factor. The scope of this study was only to look into the impact of LTSM available for the students keeping other parameters unchanged as much as possible. There were two aspects in the study. First, the schools were selected amongst the schools which have resource gap. Second, the sample was selected considering the homogeneity in terms of home language, socio cultural background and pedagogy used in the classroom. If the socioeconomic factor is a sufficient condition for learners' performance, then it can be asserted that learners from school supported by different LTSM would perform significantly better than their peers from the other school where learners were not provided with different LTSM. Through this study, an attempt was made to empirically identify the impact of resources on Chemistry teaching-learning outcomes on learners' academic performance in a single community of rural South Africa where teaching mainly takes place via teacher-centered note-and-question-paper solving method. Two schools were selected so that one school was supported by more modern LTSM over the other school. Both the schools were situated under the same municipal area. The learner population in both the schools were racially homogeneous. They were using the same home language and belonged to the same municipal area. In such cases, disadvantaged learners will be performing poorer than the socio-economically advanced learners.

Principals of a private school from the local town and a public school from a nearby village agreed to take part in the study. It is to be noted that all learners from the private school were provided a tablet as a part of study material along with other traditional materials used in the classroom. On the other side, the public-school learners were solely dependent on class notes, textbook, and old question papers to carry with their studies. No electronic-based LTSM were available at the public school. In this study, performances of grade eleven learners in a chemistry test were empirically compared. This study attempted to identify the correlation between socio-economic factors with the outcomes of chemistry teaching-learning activities.

Research Design

This study followed a quantitative method of research. Quantitative data were collected by a correlational and experimental method for quantitative data collection (Waters, 2019). A post-study-controlled test was used to collect the quantitative data regarding chemistry teaching-learning outcomes that took place throughout a year in respective classrooms selected by the researchers. Quantitative data were obtained from a controlled test which was administered by the DBE, Mpumalanga Government. The test was held at the end of the academic year in 2015. Performances of learners were collected and analyzed. The number of learners passed in each question for the selected schools were identified and used for statistical analysis.

Population and Sample

Schools from a rural municipal area under Mpumalanga province of South Africa were the targeted population for this study. Learners of this area were using Si-Swati as their communication (home) language and English as their classroom instruction language. It was also observed that most of the public schools from these areas lacked in modern ICT components as their LTSM. One private school within the same area was identified to have sufficient ICT based LTSM for different classroom activities. Learners of this school were supplied with tablets for their daily learning activity from home.

On request from the researchers, two schools agreed to participate in the study. Permission was provided from school administrators of both the participating schools. It was agreed on the ethical grounds that neither of the schools will be identified in the study nor the individual learner be exposed to their performances. All records were maintained anonymously. There was no funding received for this study.

Grade 11 Chemistry classes from these two conveniently selected schools were considered as samples. The samples were chosen so that both the sample may contain an almost equal number of members. Bearing in mind practicality, it was found to be very difficult to involve two same class groups from the same population simultaneously. The size for both the selected sample groups were quite closer. 49 learners in school A and 40 learners in school B and were considered statistically adequate for the study.

Following observations were made.

- Both sample groups had size similarities.
- Both sample groups comprised of learners having the same socio-cultural background.
- Both the sample groups belonged to the same linguistic community. It was Isi-Swati as the home language and English as the instructional language.
- Both the teachers' code-switched in the classroom instruction process (Lin, 2013).
- Both the teachers used traditional, lecture, note delivery methods and previous question papers solving processes during the teaching-learning process.

Teachers from school A used Tablet, WiFi links, Smart Board, Text Books, Overhead Projectors, Laboratory, Library, and Old Question Papers as LTSM. On the other hand, teachers from school B used Chalkboard, Old Question Papers, Text Books, and Overhead Projector as LTSM. Teachers from both schools used similar pedagogical methods to teach chemistry. Teachers in both schools were using traditional teacher-centered methods to teach (Kazeni & Onwu, 2013; Markic et al., 2016). It was also informed that grade eleven learners from school A observed at least four different practical experiments (using video clips of practical experiments and live by the subject teacher). On the other hand, grade eleven learners from school B could observe only two experiments demonstrated by the teacher. No learner had hand-on experience with a chemistry practical experiment. Apparently, there were no differences between the two groups in terms of the classroom size and intervention method. Under these specific circumstances, performance analysis of both the sample groups should assist to understand the effect of resources on chemistry teaching-learning outcomes. The intention was to gather some empirical evidence about teaching-learning outcomes in chemistry using these two schools.

Testing Instrument

Every year DBE administers a controlled test to determine learners' knowledge and hence their eligibility to proceed to grade twelve. Physical Science Paper 2 (Chemistry) for learners who were studying in Grade 11, for the year 2015 was used as a testing tool for this study. The tool had a total of 10 separate questions covering the contents taught to learners through the year. It was considered standard, valid, and reliable for measuring teaching-learning outcomes in Chemistry for both the sample groups because the tool was prepared by the Mpumalanga DBE. The test was administered by the Mpumalanga DBE simultaneously in all schools of Mpumalanga. Performances of all 89 learners from both the schools were collected and recorded anonymously.

The chemistry question paper which is known as physical science paper 2, used as a testing tool in this study had ten questions and was arranged as follows. Question 1 covering all the topics taught during the academic year. Questions 2 and 3 included bonding and properties. Question 4 carried questions on gas laws. Stoichiometry and determining empirical formula were covered by question 5 and 6. Question 7 included exothermic and endothermic equations. Questions 8 and 9: Questions on acid-base reaction and redox reactions were asked in question numbers 8 and 9. Question 10 was based on metallurgy.

Data Collection

November examination scores for Grade 11 learners' studying, Physical Science Paper 2 for the year 2015 were considered for the purpose of this research. Data were collected after the test was implemented, moderated and announced to the learners. Primary raw data were collected in terms of pass or fail in a question instead of collecting actual scores of the learners in a given question. A score of 30% was considered as pass in a given question. A value of 41 for a given question number implied 41 learners of that school passed in that specific question. Collected data were then analyzed in two different steps. They were descriptive analysis and inferential analysis.

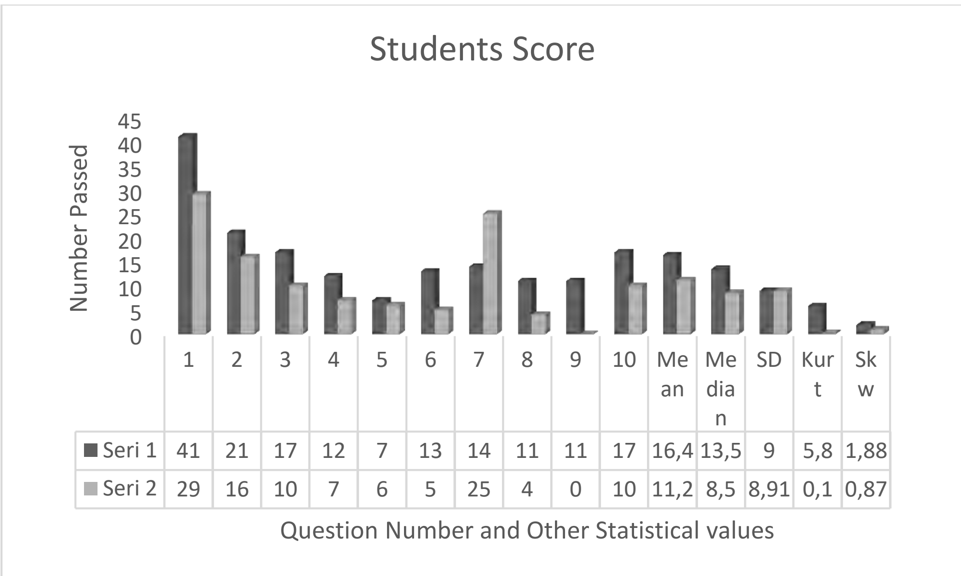
Data Analysis

Initially collected data were arranged and descriptive statistics were calculated from the arranged data. Calculated mean, median, standard deviation, kurtosis and skewness are then presented in figure 1. The data indicates that performance of learners from both the schools exhibits a higher standard deviation value. This indicates diversity of scores within the population. Performance is not confined within few learners. In case of school B kurtosis is very low means data collected from this school is almost normal. On the other hand, school A exhibits a higher kurtosis value means data collected from this school is nonparametric in nature.

Results

Figure 1

Graphical Presentation for Data & Vital Statistics



The graphics presenting number of learners passing in each question is given in figure 1. Number of learners passing in each question for school A is given in series 1 and number of learners passing in each question for school B is given in series 2 (Figure 1). At this stage it is clear that data collected cannot be treated as parametric data set.

This information is then taken further for their inferential analysis. In case of inferential analysis performance of learners from two schools are compared and guide line for analysis of nonparametric data followed (Ratner, 2009; Chan, 2003).

For both the sample schools mean is higher than median. A higher value of standard deviation also indicates the spread of data in the distribution. It means there is a gap in learners' performances in both the groups. A quartile distribution for both the group is calculated and presented in Table 1.

Table 1

Quartile Deviation

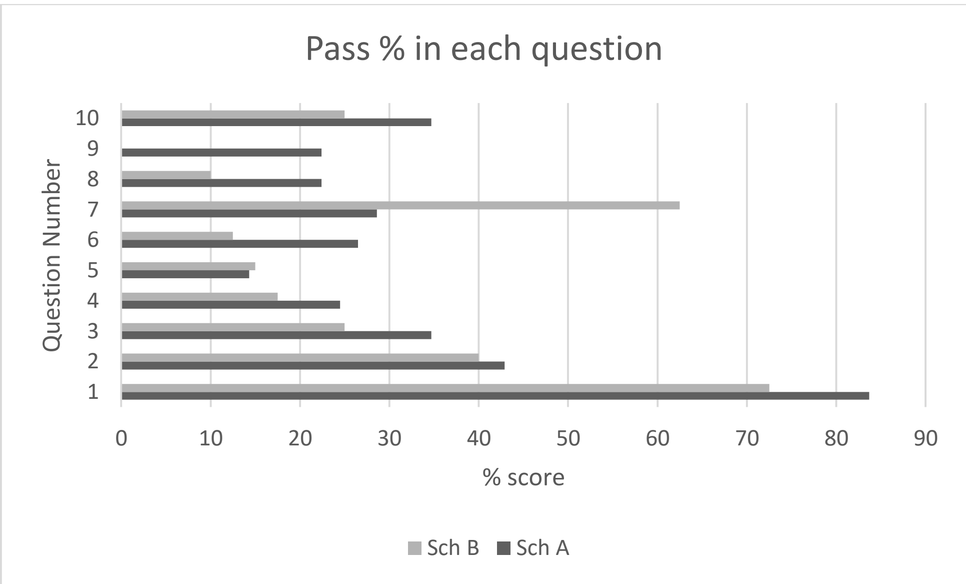
	Quartile Deviation	
	B	A
Q 1	5.25	11.25
Q 3	14.5	17
Q 3- Q 1	9.25	5.75
Q 3 + Q 1	19.75	28.25
Co-eff. QD	0.468	0.202

A difference in coefficient of quartile deviation amongst the two data sets is observed. Data set B is almost two times spreader than data set A. It indicates that the performance of learners from under-resourced school was widely spread and performance of learners from resourced school was comparatively confined within a limit and less spread.

Few common trends are observed in learners' performances. Learners from both the resourced (School A) and the under-resourced (School B) schools are performing well in question number one. More than seventy percent of learners passes in question one for both the schools (Figure 2).

Figure 2

Bar Graph Comparing Pass Percentage



Question number one consisted of a combination of ten multiple-choice questions and learners were required to find the correct answer from a given set of five answers. It is argued that learners' ability to recall and write assisted them to perform in question number one. Another presumed factor is the guesswork of learners. Another similarity in performance trend is less than 40% pass rate in all questions for learners from both the samples except question two and seven. Question number two (covering contents of bonding) where learners from both schools exhibits more than 40% pass rate. The school with better resources performs a little better than the under-resourced school. In question number seven (covering contents of exothermic and endothermic reactions) under-resourced school outperforms the learners from the resourced school by 63% pass over 25% pass. Resources were not necessarily helping school learners to perform better. While observing the overall performances it is concluded that performances of learners from both the schools is very poor in the given Chemistry test.

The next consideration is to assess more existing evidence to find if there is any statistically significant difference in the performances of learners from the selected schools. Statistical analysis of learners' performances is presented for this purpose. The central tendency (Figure 1) values for the resourced school shows a higher trend when compared with the under-resourced learners' performance. The findings reveal that more learners from the resourced school passed. Performance of learners from both resourced school and under-resourced schools was not uniform as evident from their standard deviation values.

Collected data are skewed and nonparametric (Mean >Median, Figure 1.). School A exhibits a positive skew with a higher kurtosis value (Figure 1). Hence data obtained for school A was found to be leptokurtic. Performances record for school B exhibits an almost normal distribution with a very small kurtosis value. Due to the skewed nature of a set of data a chi-square test is performed for identifying the significance of test results. While doing so, learners having advanced LTSM treated as a treatment group. Hence A was the treatment group that was provided with different advanced LTSM considering there will be a significant performance improvement when compared to group B which was lacking in any advanced LTSM. There were 10 questions and 49 participants in group A. Hence total responses obtained from this group were 490. Similarly, group B had 40 participants generating 400 responses. Arranged data are presented in table 2 with observed and expected frequency. Two groups are making two members in the column and two outputs pass and fail makes two rows.

Table 2

Observed and Expected Frequencies and Chi-Square Value for Learners' Performance

	Passed (P) Observed Frequency (O)	Failed (F) Observed Frequency (O)	Expected Pass Frequency (Calculated) (E)	Expected Fail Frequency (Calculated) (E)	Total Observations
Treated (A)	164 (AP)	326 (AF)	152(AP)	338(AF)	490
No treatment (B)	112(BP)	288(BF)	124(BP)	276(BF)	400
Total (Σ)	276	614			890
$(O – E)^2$ / E AP					0.947
$(O – E)^2$ / E BP					1.161
$(O – E)^2$ / E AF					0.426
$(O – E)^2$ / E BF					0.522
$\chi^2 = \Sigma [(O – E)^2 / E]$					3.056

Calculation for the χ^2 (chi-square) value for the obtained data is also presented in table 4. In this, the degree of freedom (df) is calculated as (Row – 1) X (Column – 1). Since there are two rows and two columns, we get (Row – 1) X (Column – 1) = (2-1) X (2-1) = 1.

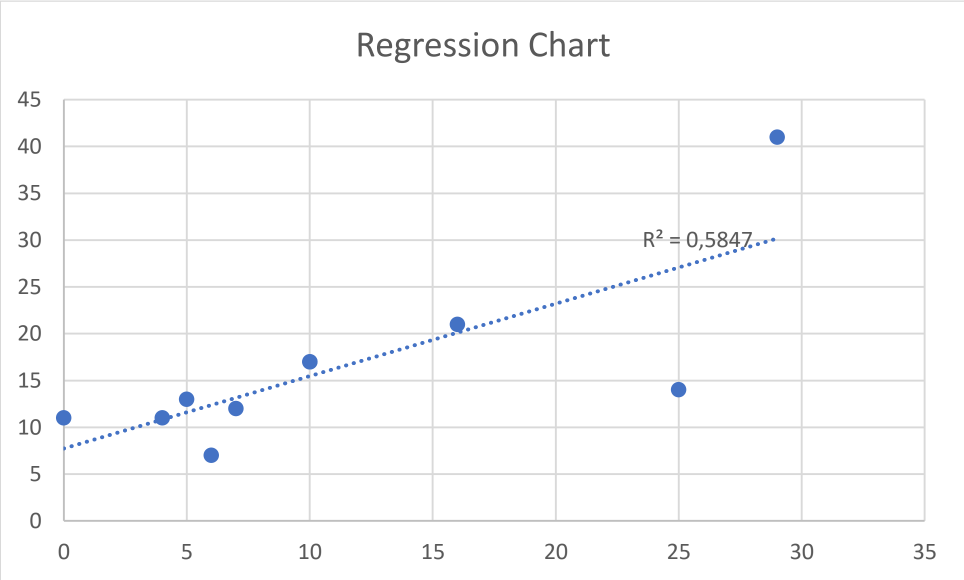
In order to the collected data being significantly similar, observed χ^2 (chi-square) value should be equal or less than the pre-determined critical value of χ^2 (chi-square) as given in the χ^2 (chi-square) value table (accessed on 15th April 2020). It was found that for a degree of freedom 1 observed χ^2 (chi-

square) value was 3.056 (Table 2). Critical value for χ^2 (chi-square) (chi-square table, accessed on 15th April 2020) for the same degree of freedom 1 is given as 3.841, having $p<0.05$.
Hence;3.056 (observed χ^2) < 3.841 (critical χ^2).

Hence, it is concluded that performances of treatment group A are significantly similar to that of the base group B. In order to determine whether the data set are closer in their similarity, a regression value was calculated which indicates the nature of similarity of two different data sets. A regression test was performed on the obtained data sets from learners' performance. A regression graph is drawn from the test performances of learners (Figure 3).

Figure 3

Image of Excel Page Calculating Regression Value



While studying the regression graph, data for B is placed along X-axis as the independent variable and compared with data obtained from A as the dependent variable. A regression summary output of the data in excel software provides R^2 value of 0.58 which indicates that at least 58% similarities between the data of B and A. The same regression summary provides p values for X-variable as 0.01 and for intercept as 0.05. Hence it is observed, $p<0.05$, means the similarities are highly significant. It is advised that Pearson's correlation coefficient is a strong tool to measure linear relationship between two different data sets (Ratner 2009). The calculation for correlation coefficient produced a value of $r = 0.76463$. This indicates a strong positive linear relationship through a firm linear rule (Ratner 2009).

These observations help to conclude that resources did not exclusively assist in performance enhancement. It means that there is no statistically significant difference between the two score sets collected after administering the chemistry tests to the learners. Hence null hypothesis is rejected in light of the given set of data.

Discussion

Studies have suggested, household wealth is significant in predicting how well children do in school (Chowa, Ansong, and Masa, 2010; Filmer & Pritchett, 2001). There is a belief that the availability of resources can only improve the learning outcomes. This study attributed to the existing knowledge base of this faith. This work empirically observed the changes in learning outcomes of two different strata of the society the rich and the poor and compared them. It has established the fact that learners do perform poorer even when assisted by advanced ICT based LTSM. This contradicts the theory that suggests only the affluent can have better opportunities in educational environments (Reddy, 2006). Even though success of using high end technology (Hsiung, 2018) has been hailed training for classroom educators is placed on priority (Boesdorfer, 2019). Whether advanced technology is used or not it is important to stress on the pedagogy to be used in the classroom to create a learning environment. This study established that poor performance of learners from a technically equipped classroom is as equitable to the poor performance of learners from a classroom having no technical support. It also indicated; advanced LTSM had a statistically negligible influence on chemistry learning outcomes on the selected samples. In addition, it strengthens the findings that proposed "lack of educational software, lack of internet access for learning, and lack of teaching materials, exert a minor influence on the achievement of teaching-learning outcomes" (Savasci & Tomul, 2013). Authors agree that learning outcomes are mostly influenced by teachers' classroom practices (Wenglinsky, 2002). Hence it is important engaging the teachers to learn how to develop chemistry or science topic specific pedagogic content knowledge (TSPCK) rather than providing them with technical gadgets. Most probably there is a need to reflect on the issue of empowering science teachers with subject and TSPCK to improve their classroom practices. While using digital teaching materials training of teachers found to play an important role delivering better learning outcomes (Ozden, 2019). This goes in line with the observation where a need for teachers' training is emphasized prior to introduce any LTSM including textbook (Milligan et. al. 2018). It is also suggested that quality of science education increases with teachers trained in skill development for 21st century science teaching skills (Zorlu & Zorlu, 2021). Now, there can be said that in improving readiness to teach science in 21st century by providing training to the science teachers (Ngaisah et al, 2018). Instead of loading schools with advanced gadgets in the name of providing quality science education, science teachers are to be trained on how to use inquiry-based teaching in teaching science for both resourced and under resourced schools. Efficacy of inquiry-based teaching has been established by different academicians under different teaching-learning environment (Küçük, 2022; Makwinya, McKinnon, & Lummis, 2022; Madhuri, & Goteti, 2022; Li et al., 2022.)

Conclusion

This study was aimed at empirically identifying the impact of advanced LTSM of a school in chemistry teaching-learning outcomes compared to a school having minimal LTSM. Although this study was limited to a relatively small sample of a confined municipal area, it had the advantages of studying the chemistry learning outcomes by keeping several variables almost constant where socioeconomic status was different for the sampled students. This study has successfully pinpointed the relationship between socioeconomic status and chemistry learning outcomes. Sample of learners were from the same community studying under different learning environment. Both the groups in this study were having the same sociocultural behavior, same religious faith, same linguistic background, and were taught by their teachers using the same traditional method of teacher-centric teaching method. Both the schools had almost similar teaching-learning environment. Observation of this study contributed an answer to the fact that, if there exist certain common traits, do the resources become the sole contributor to better chemistry learning outcomes. It is observed that resources might help in performance enhancement, but it is not the necessary and sufficient condition for improving chemistry teaching-learning outcomes.

This study suggests that instead of blaming government agencies for the lack of resources, it is important to look for appropriate pedagogy using the available resources to teach Chemistry. Findings of this study advice to use a pedagogy that contributes in developing an appropriate attitude amongst chemistry students since academics in recent works mentioned attitude as a main contributing factor towards better learning output. There is a need for conducting studies to identify factors that could improve learning outcomes of chemistry classes without causing financial burden on the rural schools as well support schools bring a new learning environment that is conducive for effective science learning.

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