The effect aural learning styles have on the performance of the first-year University of Namibia Mathematics students when learning solving quadratic equations

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Abstract
This study examined the effect aural learning styles have on the performance of the first-year University of Namibia mathematics students when solving quadratic equations. The study was fuelled by the persistent problem of poor performance in Basic Mathematics, a first year module for pre-service mathematics teachers. Against the foregoing background, the objective of the study was to find out if there are statistically significant differences in the students' performance with aural learning styles when learning to solve quadratic equations. The study was underpinned by Flemings' VARK Model developed in 1987. Quantitative methods approach was used to gather data from the participants. A single-group design utilising pre-test-post-test with an intervention was employed to collect quantitative data. The quantitative data were analysed using t-test, to test the hypothesis that there is no statistically significant difference in the first-year students 'performance using aural learning style during the pre-test and post-test when learning to solve the quadratic equations. The study population comprised 469 first-year Mathematics students and drew data from a sample of 45 students. The participants were selected through convenience sampling and random sampling, and taught on different times using different strategies (Power point presentations, lecturing and self-study). The main finding of the study revealed that there were statistically significant differences (the test scores, $t(44) = 2.015$, $\rho < 0.001$ at $\alpha < 0.05$ confidence level) in students' performance with aural learning styles during the pre-test and post-test when learning to solve the quadratic equations. The study also found that the study the students perform better when the teaching methods are aligned with their learning styles. Based on the findings the study recommends that that the lecturers use teaching strategies that are suitable for aural learning styles such as lecturing and audio recordings.

Keywords: *aural learning style, VARK model, basic mathematics, students' performance, solving quadratic equations*

Background of the study

Different factors influence performance in Mathematics, such as social, economic, personal, and school factors (Mbugua et al., 2012). Achievement in Mathematics is a fundamental indicator of the performance of a school system in any country (Bosman & Schulze, 2018). Shahrill et al. (2013) noted that Mathematics students do not perform well when they use inappropriate learning strategies. Also, several studies (e.g. Bosman & Schulze, 2018) found that poor performance in Mathematics may also be related to the teaching style of the teacher since prolonged mismatches between the teaching style in the classroom and the learning styles of most learners can contribute to poor academic achievement and negativity towards a subject. The study used Flemings' VARK model to compare the performance of the students using aural learning styles during the pre-test and post-test. The model was ideal for this study as it clearly explains that we use our senses to learn (Jaleel & Thomas, 2019). The model classifies individuals as visual, auditory, reading, and kinaesthetic according to the senses they use to learn. In this study, students were assigned randomly to find out their performances against their preferred learning styles.

Currently, the teaching strategy used at the university is the lecture method associated with auditory learning styles. Kwembeya and Mbukusa (2019) recommended in their studies that there is need for a study at the University of Namibia (UNAM) to find out if lecturers teaching strategies address students' learning styles. As stated earlier, mismatching the teaching styles and learning styles are believed to affect students' performances negatively, therefore the current practice (lecturing) might affect other learning styles such as visual and kinaesthetic. The main objective of this study was to investigate the effect aural learning style has on the performance of first-year University of Namibia mathematics students

when learning to solve quadratic equations. The study used quantitative research methods to examine the effects aural learning styles have on the performance of the first-year university students. To collect quantitative data, the study used an experimental research design, consisting of a pre-test and post-test. The population of the study consisted of a total of 469 first-year Mathematics students and a sample size of 45 students of the University of Namibia.

In 2011, the University of Namibia introduced the two streams (fast and slow streams) but there was no visible improvement in the first-year mathematics students' performance. Slow stream was design for the students who were underperforming, to give them more time (a year) to master the content whereas the fast stream was for only for six months for students believed to be performing well. The students were still underperforming after the introduction of the two streams, as can be seen from the results in 2013 and 2014, when only 55% and 36% respectively, passed first-year mathematics at the selected campus (R. Ihemba, personal communication, August 27, 2015). Moreover, the performance of students in the test which covers solving quadratic equations was very low. The average performance in the first-year Mathematics at the University of Namibia was 41% (2020) and 37% (2019) over the last two years (Examination Department, University of Namibia, 2022).

Research question and hypothesis

The study addresses the following research question and hypotheses:

Research question

1. How does the aural learning style affect the performance of the first-year mathematics students when learning to solve quadratic equations at the University of Namibia?

Hypothesis:

H_0: The aural learning style has no effect on the first-year students 'performance when learning to solve the quadratic equations.

H_1: The aural learning style has no effect on the first-year students 'performance when learning to solve the quadratic equations.

Literature review

Definition of learning styles

Ellis (cited in Xu, 2011) defines learning styles as the distinctive ways individuals orientate to problem-solving. The study embarked on finding out how first-year mathematics students using aural learning styles solve problems involving quadratic equations. Individual learning style refers to style or learning methods used in the process of learning. Jantan and Razali (2002) as cited in Othman and Amiruddin (2010) explained that psychologically, as a learning style is the way the student concentrates, and their method in processing and obtaining information, knowledge, or experience. On the other hand, from the cognitive aspect, learning style can refer to various methods in perception creation and information processing to form concepts and principles (Fleming & Baume, 2006). Lebar and Mansor (2000) as cited in Othman and Amiruddin (2010) explained that learning styles refers to a preferred strategy and technique utilized by individuals while studying. Learning styles involve individual's tendency to perceive and process information, not learning skills (Othman & Amiruddin, 2010). In this study, the focus is on how students perceive information through the use of different senses and the effects, they have on students' performances, specifically aural (hearing).

Different types of learning styles/models

There are different learning style types; perceptual learning styles, cognitive learning styles, and personality learning styles (Xu, 2011). According to Xu (2011), "cognitive learning styles include focuser and scanner, serialists and holists, divergent thinkers, field dependence (global leaner) and field independence (analytic learner and personality learning styles are reflective learner and impulsive learner" (p. 415). The current study focuses on perceptual learning styles (sensory learning styles) that deals with one's ability to use different senses (hearing, seeing, and touching) to learn. The following models are based on the definition of the learning styles. There are different types of learning style models such as Kolb' experiential learning style (1984), Felder-Silverman learning style model (1988), Dunn and Dunn learning style model (1978), Witkins (1981) Field dependence/Field- Independence learning style model, and Fleming's VARK model (1987) to mention a few (Cassidy, 2004). This study employed Fleming's VARK model. One of the most common and widely used categorizations of the various types of learning styles is

Fleming's VARK model (sometimes VAK - an acronym for the Visual (V), Auditory (A), and the Kinaesthetic (K) sensory modalities) which provides the learners with a profile of their learning styles, based on the sensory modalities that are involved in taking in information (Sreenidhi & Tay, 2017).

Fleming's VARK model

The research is based on Fleming's Visual Aural Reading and Kinaesthetic (Tactile) model known as the VARK learning style model, developed in 1987 (Sreenidhi & Tay, 2017). Fleming's VARK model is sometimes referred to as VAK and it is based on the sensory modalities that are involved when one is learning new information (Sreenidhi & Tay, 2017). Fleming's VARK learning style theory explains that one prefers to learn through one of these sense channels, which are visual (to see), aural (to hear) and kinaesthetic (to touch) (Jaleel & Thomas, 2019). In this study focus is only on aural learning styles.

Norasmah and Amiruddinb (2010) suggested that dividing students according to learning styles is necessary so that the effectiveness of each lesson to different VARK learning mode can be observed. Flemings VARK model was considered suitable for this study as the model fully describes the different types of learning styles that an individual can use when learning new material. Fleming's VARK model is suitable for this study as the model clearly explain the different learning styles by fully describing different ways each learning style uses to learn new information, and aids in comparing the performances during the pre-test and post-test of the students with aural learning styles. Several other studies (such as Othman & Amiruddin, 2010) have used Fleming's VARK model to compare the performance of students with different learning styles and found the model to be reliable and consistent.

Aural learning styles

Aural students learn something by listening (Drago & Wagner, 2004). These students give more attention to the words delivered by teachers. They prefer to listen than writing lecture notes. After lectures end, they choose to discuss topics which were taught with classmates, as a way to clarify their understanding. To aid with their learning style, aural students discuss on answers or by listening to recording over the examination topics. Students who learn with this mode are easily interrupted by noise. This type of students can remember information through loud reading or mouthing when reading, especially when learning something new. Students can strengthen their memory by listening again to again to audio tape recordings, by teaching other people and discussing with teachers. Sreenidhi and Tay (2017) also define auditory learning as a learning style in which an individual learns through listening. An auditory learner depends on hearing and speaking as the primary style of learning. Auditory, these individuals discover information through listening and interpreting information by the means of pitch, emphasis, and speed. These individuals gain knowledge from reading out loud in the classroom and may not have a full understanding of information that is written (Syofyan & Siwi, 2018).

The effects of aural learning styles on students' academic performance

A study in Namibia found that the mathematics teachers indicated that learning styles have both positive and negative effects on the teaching and learning of Mathematics (Silas, 2013). The learning styles impact the students' overall academic achievement (Abidin et al., 2011). Aligning the teaching strategies with students' learnings styles increases students' performances (Bosman & Schulze, 2018; Dunn et al., 1989 as cited in Abidin et al., 2011).

In this study, the researcher wanted to find out the effect the aural learning style has on the performance of the first-year students when learning to solve quadratic equations at the University of Namibia. Most students favour to learn in particular ways with each style of learning contributing to the success in retaining what they have learnt. These facts reveal that each learning style has its own strengths and weaknesses (Abidin et al., 2011). Understanding students learning styles (weaknesses and strengths) is very important when planning lessons, as this will help in improving students' performances.

A study by Khan et al. (2019) found that auditory learning preference scores and total learning preference scores had significant correlation with academic achievement of college students. The study examined the effect aural learning style has on students 'performances and therefore, the findings mentioned here by the researcher are important

for the analysis of this study as the findings of this study will confirm or disprove the findings by Khan et al. (2019). A study by Shahrill et al. (2013) found the more able mathematics students as stronger users of the auditory-language learning style than their less able peers. Another study conducted by Leung and Sabiston (2014) found that all learning preferences (visual, auditory, and kinaesthetic) had non-significant correlation with academic achievement of university students. The current study sought to confirm or contradict the findings of Leung and Sabiston (2014) by testing several hypothesis as stated before although focusing only on aural learning style .

Different views about learning styles

Hatami (2012) states that; the proponents of learning styles assessment in instruction believe that learning styles can be measured and used as a valuable teaching tool inside the classroom. The findings of this comparative analysis show that in tertiary education, learning styles vary significantly among different disciplines, such as, engineering, medicine, dentistry, nursing, and social sciences (Hatami, 2012). It is also seen that in the same discipline students' learning preferences are different (Mirza & Khurshid, 2020). This study aimed to find out the effect the aural learning style has on the performance of the first-year students at the University of Namibia.

Implications of learning styles for teaching and learning

Drago and Wagner (2004) commented that achievements in educational field depend much on the ability of the teacher to adapt lessons based on each individual's aspects and that a teacher should be creating an environment to fulfil the demand of students' various learning styles, as well as knowing the importance of teaching by using various learning styles. Although most of the studies found that students perform better when teaching instructions are aligned to their learning styles, several other studies (Rohrer, & Pashler, 2012; Rogowsky et al., 2020) have questioned the methodologies used to support this hypothesis as most did not used experimental designs. In summary, there is presently no empirical justification for tailoring instruction to students "supposedly different learning styles" (Rohrer & Pashler, 2012, p. 636). Rohrer and Pashler (2012) carried out empirical research and found that the hypothesis might not always be true, meaning that instructions alignment with learning styles does not always improve performance. Firstly, the participants were given learning style questionnaires to complete and then randomly selected to participate in the pre-test and post-test (experimental research design) to find out if aligning teaching instructions to learning styles have any effects. The questionnaires were merely used to identify participants preferred learning styles. Others also commented that, although many believe that teaching according to learning styles improves performances, there is no extensive experimental data and strong theoretical arguments to support such claims (Alcock & Hulme, 2010).

Learning styles in Namibian context

A study by Kwembeya and Mbukusa (2019) found that most of the students at UNAM doing biology are multimodal (61.3%), meaning that they use more than one learning style. They also recommended that the lecturers should critically reflect on their teaching strategies and change their teaching to address different learning styles in the classroom issue. Shumba and Iipinge (2019) found nursing students in Namibia are also multimodal. In their review of various literature Shumba and Iipinge (2019) found that most of the articles/recearch acrried out found a positive relationship between the learning styles and teaching styles. At school level teachers are also encouraged to align their teaching strategies with learners' learning styles to improve performance (National Institue of Educational Development, 2014). These recommendations by the National Institue of Educational Development highlight the need for educators at all levels to adopt flexible and inclusive teaching approaches that cater to diverse learning preferences, ultimately promoting more effective learning outcomes.

Overall performance in Mathematics

Mathematics failure rates at the University of Namibia, especially among first year modules, have been extremely high for the past ten years (Miranda & Gideon, 2011). A study by Jacobs and Pretorius (2016) at the University of Johannesburg found that students (46.4%) who scored more than 60% in grade 12 Mathematics failed in their first year; they

scored less than 50 %. The same study also found that three students who scored more than 90% in grade 12 failed first-years mathematics.

Students understanding of solving quadratic equations

Barbieri and Booth (2020) and Hu et al. (2021) commented that **s**olving quadratic equations is one of the topics which are found to be challenging for most of the students. Furthermore, Hu et al. (2021) commented that students lack both procedural and conceptual understanding when it comes to solving quadratic equations and that students have a difficulty to understand the zero-product property (ZPP). A study by Ganesen et al. (2020) found that there is a positive correlation between the learning styles and achievements of solving algebraic problems. The findings by Ganesen et al. (2020) is of greater interest for the current sudy as they have also investigated the correlation between the learning styles and students' performances, more specifically focusing on solving algebraic equations which is the focus of this study.

A quadratic equation refers to a polynomial (trinomial) with the highest degree of two or a polynomial with highest power of two and has at most two values of the variable when it is solved. Quadratic equations are written as: $ax^2 + bx + c = 0$ in which $a, b \; and \; c$ are constants with non-zero values. The methods of solving quadratic equations are factorisation, completing the square, and the use of quadratic formula (Hu et al., 2021).

Aural learning and solving quadratic equations

Aural or auditory learners, on the other hand, prefer learning through listening and verbal explanations (Othman & Amiruddin, 2010). For quadratic equation solving, these individuals may thrive in environments where explanations are provided through lectures or verbal problem-solving demonstrations. Research by Hu et al. (2021) has indicated that aural learners might find it easier to understand and remember quadratic equation-solving steps when they are explained verbally or through discussions.

Research methodology

The study employed a quantitative research method. Both quantitative and qualitative data were collected investigate the effect aural learning styles have on the performance of the first-year UNAM mathematics students. The study was more of a true experimental (single-group) research design utilising single-subject design. The population of the study was 469 registered first-year students in Basic Mathematics during the 2022 academic year at this specific campus. The study sample consisted of 119 students. Random sampling technique was used to select the sample together with random sampling. Students were provided with numbers from one to 100 and those who picked even numbers wrote the pre-test and the post-test.

Data collection procedures

Clearance was obtained from UNAM's decentralised ethics committee. The researcher made appointments with students, the pre-test was administered face to face, followed by treatments (intervention) to the group, and then a post-test was also conducted face-to-face. Since the study was a single-subject design participant were put in one group and pre-test and post-test were carried out with intervention in-between the two tests. Both the pre-test and post-test consist of several questions on solving quadratic equations using three method namely factorisation, completing the square and the use of the quadratic formula. The duration of the test was 40 minutes.

Both descriptive and inferential analysis was used to investigate the effect aural learning style has on the performance of the first -year mathematics student at the University of Namibia. The students were given a pre-test before interventions, follow by a post-test. The researcher marked both test and the marks were recorded. The interventions consisted of several lessons which were taught over a period of a week using teaching strategies believed to be suitable for aural learning styles. The treatment (interventions) consisted of various lessons taught using different strategies over a period of one week; lecturing, PowerPoint presentations and self-study. Each lesson was for 40 minutes.

Findings

Comparing the performance of students during pre-test and post-test for aural learning styles

This section presents the comparison of the performance of students during pre-test and post-test for aural group by using the measures of central tendency. In this section the study

also tested the hypothesis: The aural learning style has no effect on the first-year students 'performance when learning to solve the quadratic equations. The study wanted to compare the performance of the participants before treatment (pre-test) and after the treatment (post-test) to see if there was any difference, this was done to see if the aural learning style has any effect on the performance of the first-year mathematics students at the University of Namibia. The results for the aural group are shown in Table 1 as follows.

Table 1: Summary of descriptive data for the aural group

Measures	*Pre-test* (n = 45)	*Post-test* (n = 45)
Mean	58.333	83.778
Median	60	85
Mode	50	100
Standard Deviation	22.913	19.044
Sample Variance	525	362.677
Range	90	90
Sum	2625	3770

From Table 1, one can see that the mean score for the post-test is very high; the difference between the two means is 25.445 or 44%. The above results from the table indicate that there was a huge improvement in students' performance for the aural group. The median of the post-test (85%) is higher than that of the pre-test (60%). The difference between the medians is 25%, indicating improvement. The mode of the pre-test was 50% (7 or 16% students) and for the post-test 100% (17 or 38% students). Both the standard deviation and sample variance for the post-test are smaller than that of the post-test indicating that the results in the pre-test are widely spread out as compared to the post-test. But the range for both the pre-test and post-test is the same. The total marks scored by students during the post-test are also very high as compared to the pre-test, the difference in the total marks of all students (cumulatively) is 1145 or 44%. Here again, it shows that the treatment was effective as the difference in the scores is very high. The five-point data summaries were also obtained and these are shown in Table 2 below which shows the distribution of the marks during the pre-test and post-test for the aural group.

Table 2: Five-point data summary of the pre-test and post-test of the aural group

(n = 45)	Pre-test Marks (%)	Post-test Marks (%)
Lowest	10	10
Q1	50	80
Q2	60	85
Q3	75	100
Max	100	100

There was no difference in the performance of the students in the pre-test and the post-test when comparing the lowest and the highest mark during both tests as can be seen from Table 2 as the lowest for both groups is 10% and the highest 100%. Therefore, the difference between the highest and the lowest score was very high 90% for both the pre-test and post-test. As discussed before in the previous section, the median score of the aural group has increased by 25% from 60% during the pre-test to 85% during the post-test. The improvement in the median scores shows that the student's performance during the post-test was better as compared to the pre-test. From Table 2, one can see that 75% of the students scored more than 80% during the post-test as compared to only 25% who scored more than 75% in the pre-test.

The difference in performance is a clear indication that the treatment has a positive effect on the aural group as many students have performed much better in the post-test. Also, the third quartile of the post-test is the same as the highest mark on the test, meaning that 25% of students scored the maximum marks. For better visualisation and understanding the five data summary is shown in Figure 1.

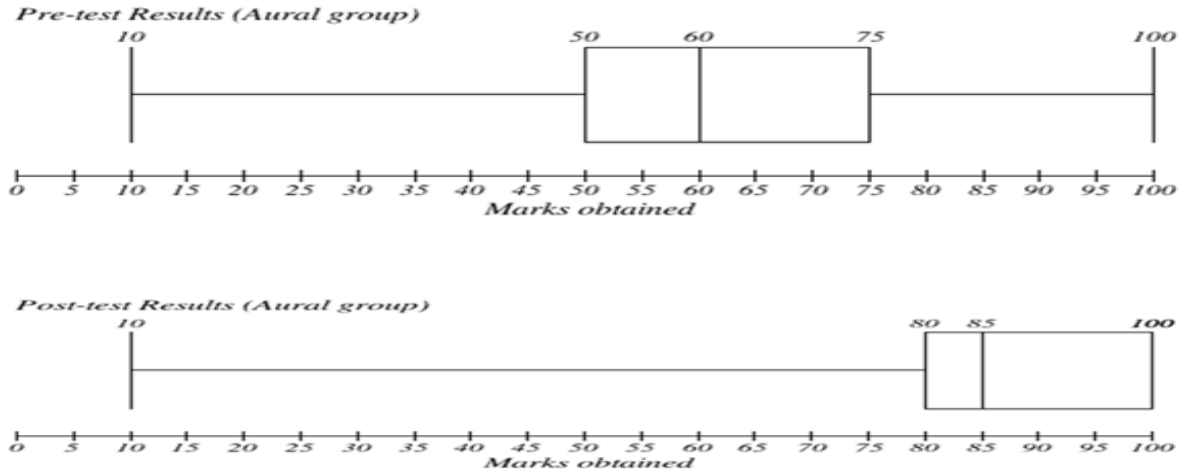

Figure 1: Box-and-whisker plots for aural group

The box-whiskers plots clearly shows the difference in the performance of the students during the pre-test and post-test. By looking at Figure 1, one can see that the performance during both the pre-test and post-test was positively skewed, although for pre-test was closer to being normally distributed. For the post-test, there was no difference between the highest quartile and the highest score as compared to the pre-test where the difference was 25%. The interquartile range of the two tests also differs by 5% because for the pre-test it was 25% and 20% for the post-test. The difference between the lower quartile and the lowest score was 40% for the pre-test and 70% for the post-test which indicates a huge difference in the performance of the participants during the pre-test and the post-test. Also, the third quartile (75%) of the pre-test was lower than the lower quartile (80%) of the post-test, meaning that 75% of the students in the pre-test scored less than 80% as compared to 75% who scored more than 80% in the post-test. The results from Figure 1 indicate a significant improvement in the performance of the students during the post-test. It might also indicate that the treatment has a positive effect on the performance of the aural group. In addition, to the previous data and to support the comparison Figure 4.8 shows the comparison of the performance of aural students during the pre-test and post. From the graph, it was obvious that the students performed differently during the pre-test and post-test. The results show that most of the students performed well in the post-test as compared to the pre-test.

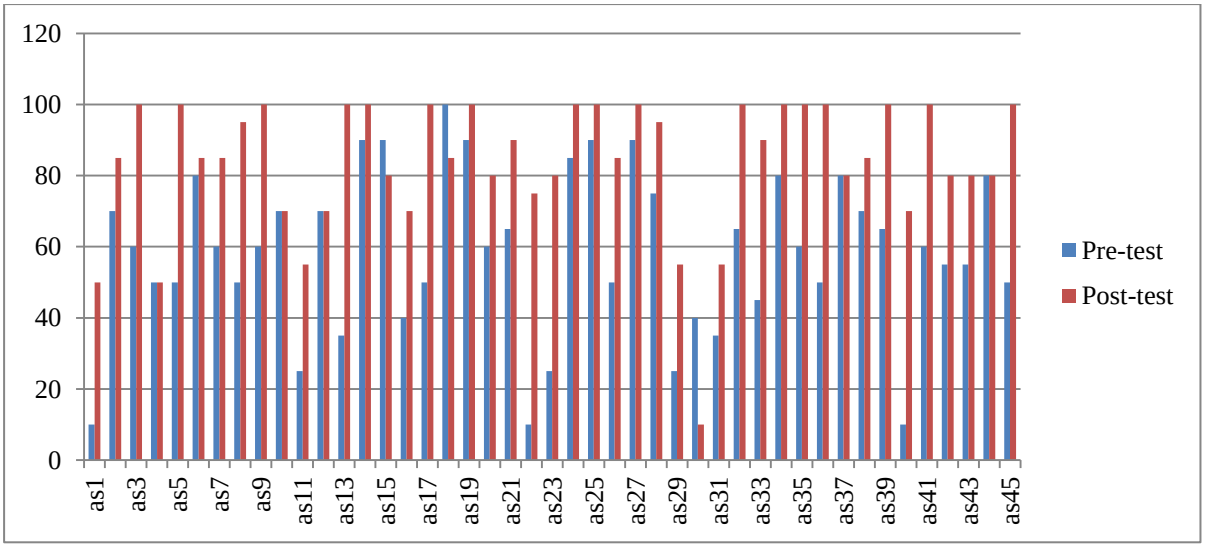

Figure 2: Performance of aural students (n = 45)

As can be seen from the graph only three or 7% of students' performances have dropped after the treatment(interventions) which included teaching using various methods such as PowerPoint presentations, lecturing and self-study. Therefore, the study concluded that the students' performances have improves when the teaching strategies are aligned with the learning styles, more specifically for those using aural learning styles. The highest decrease in the marks was by 30% from 40% to 10%. The lowest decrease was by 10% from 90% to 80%. Five or 11 % of students' performance has remained unchanged meaning the treatment does not affect the students' performance. One student scored 50%, two scored 70% and two scored 80% in both the pre-test and post-test. The fact that the performance of these students remains unchanged could show that the test was reliable and valid but other internal and external might also have influence on the performance. The performances for the remaining 37 or 82% of students have increased. The highest increase in the marks was by 65%, one from 35% to 100% and the other one from 10% to 75%. The lowest increase was by 5 from 80% to 85%. To obtain a detailed analysis (in addition to Figure 2) of a comparison between the pre-and post-test, the difference between the pre-test and post-test for each student was worked out, this is summarised in Figure 3.

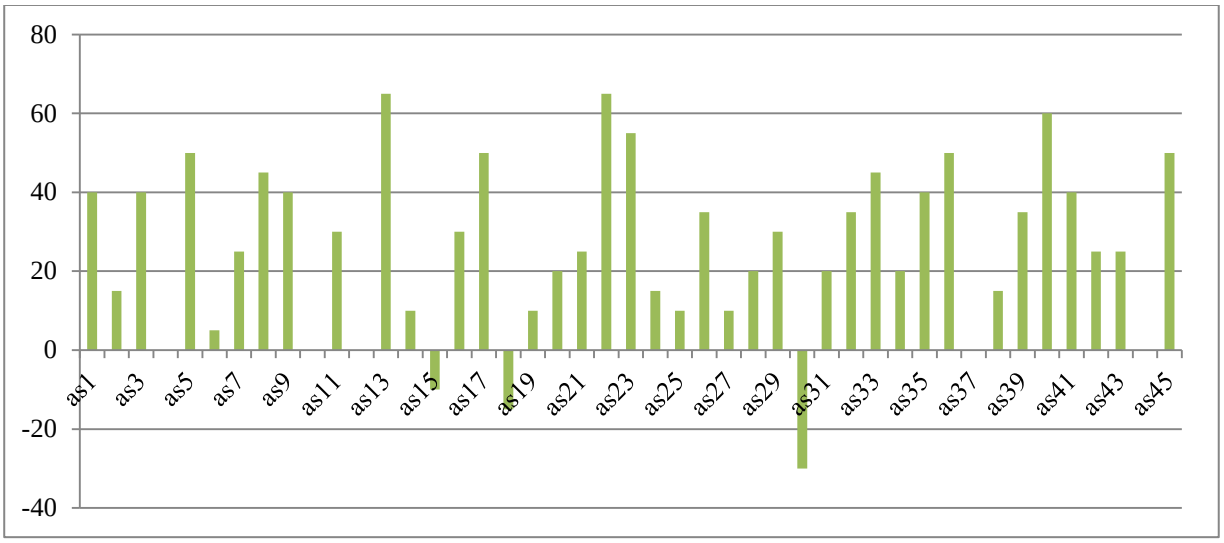

Figure 3: Difference between pre-test and post-test scores for the aural group (n = 45)

From Figure 3, it appeared that no student has scored 100% on both tests but one student' marks have dropped by 15% from 100% to 85%. Also, 17 or 38% of students' marks have increased to 100% whereby the lowest was 35% in the pre-test, indicating an increase of 65%. The study also used t-test to compare the performance of aural students during the pre-test and post-test. The results are shown in the Table 3 below:

Table 3: The t-test results for the aural group

t-test: Paired two sample for means for aural pre-test and post test		
	Post-test	***Pre-test***
Mean	83.778	58.333
Variance	362.677	525
Observations	45	45
Hypothesized Mean Difference	0	
df	44	
t Stat	7.852	
P(T<=t) one-tail	3.29217×10^{10}	
t Critical one-tail	1.680	
P(T<=t) two-tail	6.58435×10^{07}	
t Critical two-tail	2.015	

Since $\rho < 0.005$, the study rejected null hypothesis which states that the mean scores are equal and accept the alternative hypothesis that the mean scores are different. There was a statistically significant difference in the test scores, t (44) = 2.015, $\rho < 0.001$ at $\alpha < 0.05$ confidence level. The t-test statistics confirm the results from Tables 1, 2 and 3 as well as Figures 1, 2, and 3 showing that the treatment affected the students' performance positively for the aural group as there was a difference in the performance of the two groups. The students' performance has improved after the treatment which indicated that the students in this group learned better when taught using strategies for aural learning besides random assignment. Also, in the case of aural students, the results confirmed the findings by Karlimah and Risfiani (2016, 2017) who stated that when learners are taught using the methods aligned to their learning style the learners perform very well.

Conclusion

Understanding the relationship between learning styles and solving quadratic equations is an important aspect of mathematics education. Moreover, recognizing and identifying students' learning styles—and aligning instructional strategies accordingly—can significantly enhance students' performance and engagement when learning quadratic equations. This tailored approach not only supports diverse learners but also fosters a more positive attitude toward mathematics.

Recommendations

Based on the findings the study makes the following recommendation:

- The findings indicated that the aural learning style has effect on the students' performance and therefore the study recommends that the teachers or lecturers align their teaching to the aural learning style of the students/learners.

Possible areas for further studies

The study suggests that there is a need to explore how effectively teaching styles at the university (lecturing method) could be aligned with students' learning styles.

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