JORIDS

Journal of Research in Didactical Sciences

www.jorids.net

Vol. 1, Issue 1

Journal of Research in Didactical Sciences

Publisher

JORIDS is published by Nuri Balta

906 Appalachian Dr, Wylie, TX 75098, USA

Content

Journal of Research in Didactical Sciences
ISSN: 2997-5905 (Online)
VOL. 1, ISSUE 1, 2022
Article No: 12500

RESEARCH ARTICLE
OPEN ACCESS

Analysis of Mathematical Errors Committed by Grade Six Children with Mathematics Difficulties: Implications for Classroom Instruction

Seleshi Zeleke Teketel [1*]

[1] School of Psychology, Addis Ababa University, Ethiopia
* Corresponding author: sileshi.zeleke@aau.edu.et

Abstract: A growing body of research has shown that children with mathematics difficulties (MD) encounter problems in a range of mathematical tasks including mathematical computations, mathematical concepts and word problems. However, limited work has been accomplished to date that documented the children's specific difficulties or problems in each category of mathematical tasks. The present study examined whether or not children with MD face more difficulties with some operations in each category than other operations. The study selected 13 grade six children with MD from two primary schools in Addis Ababa, Ethiopia. Examination of the students' performance on a 50-item curriculum-based mathematics test showed that (i) on the computation subtest, the children performed significantly poorly on items with multiplication, division and mixed operations as compared to computation items that require addition and subtraction; (ii) on mathematical concepts, the children performed significantly worse on all items but they performed slightly better on principles and rules; and (iii) on word problems, the children performed significantly poorly on all five types of items (addition, subtraction, multiplication, division and mixed operations). Overall, the findings show that children with MD face difficulties with several types of mathematical (computation, concepts and word problem) tasks except computation items that require the application of addition and subtraction.

Keywords: children with mathematics difficulties, mathematical errors, mathematical concepts, computations, word problems

INTRODUCTION

A growing body of research has documented that children with mathematics difficulties (MD) experience problems in mathematics more frequently than their peers without MD (see Miller & Mercer, 1997). Studies have documented, for example, that children with MD encounter problems in a range of mathematical tasks including mathematical computations and word problems (Miller & Mercer, 1997; Zentall & Ferkis, 1993). Research has also shown that these children not only have lower scores on mathematics tests in comparison to age- or grade-matched typically achieving peers but function at a lower level than younger children without MD (Cawley & Miller, 1989; Fleischner et al., 1982).

In Ethiopia, like elsewhere in the world, many students consider mathematics as a difficult subject to learn. As a result, a considerable number of students hold less favorable attitude toward the learning of mathematics (Zeleke, 2001). While such conditions alone impact the students' achievement detrimentally, the school system exerts little effort, if any, to support the children. What is more, the school system does not officially recognize learning difficulties and neither diagnosis/identification nor support services are available for children with learning difficulties including those with MD. The children attend general education classes and in the absence of support services, it would not be difficult to imagine how these children are at disadvantages compared to their typically achieving peers.

The absence of routine assessment and diagnosis of learning difficulties in Ethiopian primary schools forces local researchers to begin their research from identification of the children with MD. Given the limited resources available for such research in the country, studying these children has remained a difficult and demanding undertaking. As a result, only a few studies have been conducted on these children to date. The few available studies that investigated the characteristics of primary school children with MD (Grades 4-6) in Addis Ababa, Ethiopia (Zeleke, 2004) have reported the following results.

- Children with MD scored substantially lower than their average achieving peers on all three mathematics subtests (computations, concepts and word problems) administered.
- Children with MD displayed a relatively lower level of performance on the concepts subtest than on either the computation subtest or word problem subtest.
- Children with MD performed relatively better on the computation subtest than on either the concepts subtest or the word problem subtest.

In general, the results were consistent with findings of several studies conducted in other countries (e.g., Jordan & Montani, 1997; Ostad, 1998; see also Montani, 2003). In view of the results pertaining to the mathematical concepts subtest, however, the mentioned studies provided a new insight in that children with MD not only have difficulties with word problems and computations, but also lack the conceptual knowledge necessary to solve the problems.

In light of classroom instruction, the above results may not show the big picture about the children's problems. If teachers have to use the results as a basis to support the children with MD in class, they need to know, in specific terms, about the children's problems. For example, although the results indicated that the children performed relatively better on the computations subtest, does this mean that the children are equally proficient on all kinds of computation items (e.g., items involving addition, subtraction, multiplication, division, and mixed operations)? Similar questions may be raised regarding the concepts subtest and the word problems subtest. The answers we obtain to such specific questions through research would be more useful from the perspective of classroom instruction than the results of the examination of the children's relative performance on the three subtests.

Accordingly, the items in each subtest were classified into more homogeneous sets of items and the errors committed by the children on these sets of items were examined (e.g., the computation subtest was divided into five more homogeneous sets of computation items involving addition, subtraction, multiplication, division, and mixed operations). Following this line of inquiry, the present study sought to answer the following questions.

- Do children with MD perform equally well on computation items involving addition, subtraction, multiplication, division, and mixed operations?
- Are the children equally proficient on different types of mathematical concepts items?
- Do children with MD perform equally well on word problem items involving addition, subtraction, multiplication, division, and mixed operations?

As mentioned above, the answers to these questions would provide valuable information for teachers and parents, among others, regarding the nature and specific areas of the children's difficulties. The results would also help educators and teachers to clearly understand the children's problems and the corresponding instructional interventions that are useful in supporting the children in class.

METHOD

The data analyzed in the present study is part of a relatively comprehensive data set that was collected to investigate the relationship between self-concept and mathematics achievement of children with mathematics difficulties and their classmates without mathematics difficulties. The original data set included various data gathered from children who were then attending grades four through six in two government primary schools in Addis Ababa, Ethiopia.

Participants

The participants of this study were 13 grade six children with MD (8 girls and 5 boys). At the time of data collection, the children's mean age was 13.77 years (standard deviation [SD] = 1.69). Selected from an initial pool of 188 grade six children, the children with MD displayed consistent mathematics difficulties on a curriculum-based mathematics test which was administered to the children twice with a six-month interval. More specifically, the children with MD met two criteria:

(1) scoring at or below the 25th percentile on a mathematics test at both times of measurement and

(2) scoring in the average range on the Test of Nonverbal Intelligence – 3rd edition (TONI-3) (Brown et al., 1997).

Both criteria are frequently used in research with children who have mathematics difficulties or learning difficulties (e.g., Badian, 1999; Siegel & Ryan, 1989; see also Geary et al., 2000).

Data Collection Tools

Data were collected using curriculum-based mathematics test, Test of Nonverbal Intelligence (TONI-3) and teacher ratings. The mathematics test was developed in such a way that it closely matched the mathematics curriculum for grade six. It can thus be considered as having better content validity for the present sample than commercially available standardized tests. With a total of 64 items, the original test was composed of three subtests: computations (24 items), concepts (24 items) and word problems (16 items). For the purpose of the present study, the three subtests were used but these included only 50 items. The 14 items which the author could not classify in one of the new smaller categories of items were excluded from the analysis. The internal consistency of the original test items as estimated by Cronbach's alpha was .91. Also, the test-retest reliability coefficient with a six-month interval was .84. The data analyzed in the present study were obtained from the first administration of the mathematics test.

Besides, TONI-3 was used to estimate the children's nonverbal IQ. Although a test which measures both verbal and nonverbal IQ was desirable, such a test was not available for use with Ethiopian children. As a nonverbal IQ test, TONI-3 requires each participant to complete 45 nonverbal matrices, one at a time. The authors (Brown et al., 1997) have reported satisfactory coefficients of internal consistency (above .92) and test-retest reliability (above .90) as well as evidence of validity for the test. In order to familiarize the children with the task, five practice items were administered before the 45 main items. The children scored in the average range (Mean = 84.46, SD = 8.37) on TONI-3.

Furthermore, at the beginning of data collection, teachers rated whether each child in the initial sample had reading difficulties, visual impairment, hearing impairment or speech problems on a two-point (yes or no) scale developed for the study. The 13 children with MD who participated in the present study were rated by their teachers to have none of the problems mentioned above. That is, the children had no difficulty other than MD. The teachers had ample time and opportunity (nine months of teaching) to observe the children.

Data Analysis Procedure

In analyzing the data obtained from the 13 children with MD, first the items in each subtest were classified in more homogeneous sets. The children's levels of performance or the errors they committed on these sets of items within each subtest were then compared to determine the children's specific areas of difficulties. In evaluating the children's performance on each subtest or homogeneous sets of items, 50% correct was used as a cut-off score to distinguish satisfactory and poor performance following the guideline set by the Education and Training Policy of the country (Transitional Government of Ethiopia, 1994). One-sample t-test and paired-samples t-test were used to test whether the children's performance on each set of items was significantly different from the cut-off score or from their performance on the other sets of items, respectively.

Table 1. Means and Standard Deviations of Correct Answers by Subtest

Mathematics Subtest	Number of Items	Mean	Standard Deviation
Mathematics Computation	20	7.00	2.00
Mathematics Concepts	15	2.77	1.42
Word Problems	15	3.54	1.05
Total Test	50	13.31	2.78

Table 2. Means and Standard Deviations of Scores on Computation Items

Computation Items by Operation	Number of Items	Mean	Standard Deviation
Computation: Addition	4	3.00	0.71
Computation: Subtraction	4	2.08	1.12
Computation: Multiplication	4	0.62	0.77
Computation: Division	4	0.38	0.51
Computation: Mixed Operations	4	0.92	0.76

RESULTS

First, the children's scores on the three subtests are examined. The scores of the 13 children on each subtest as well as on the total test are presented in **Table 1**. One can easily observe from the data in **Table 1** that the children's performance was generally poor relative to the 50% correct cut-off score.

The data indicate that whereas the mean percentage correct score on the computation subtest was 35 (that is, $7/20 \times 100$), the corresponding means for the concepts and the word problems subtests were 18.47 and 23.60, respectively. One can therefore say that despite their poor performance on all the three subtests, the children performed relatively better on the computation subtest. In contrast, the children committed more errors on the concepts subtest.

Admittedly, the above analysis based on subtest scores provides general information on the performance of the children. However, as argued earlier, more useful information particularly for classroom instruction could be obtained by classifying the items in each subtest into more homogeneous categories to see the difficulties of the children more clearly. The analysis presented below is done taking this argument into account.

Performance on Computation Items

The items in the computation subtest were classified into five more homogeneous categories comprising the four arithmetic operations as well as mixed operations where two or more operations are involved. The resulting scores are shown in **Table 2**. The mean scores indicate that the children's performance on the computation items involving addition and subtraction was each above average. Particularly on items involving addition, the children's mean percentage score was 75, which is significantly higher than the criterion score (50% correct) for satisfactory performance ($t = 5.10$, $df = 12$, $p < .001$). This means that even though the children have mathematics difficulties, they perform well above average on the computation items involving addition.

The children's performance on subtraction items was also satisfactory. However, unlike the mean score for the addition items, the mean score (52% correct) on subtraction items was not significantly larger than the criterion score ($t = 0.25$, $df = 12$, $p > .05$). Thus, the children had average performance on subtraction items.

In direct contrast, the mean scores on those computation items involving multiplication ($t = -6.50$, $df = 12$, $p < .001$), division ($t = -11.50$, $df = 12$, $p < .001$), and mixed operations ($t = -5.11$, $df = 12$, $p < .001$) were far below average or significantly lower than the criterion score. Put differently, the children committed a large number of errors when the computation items involved multiplication, division, or mixed operations.

The use of paired-samples t-test similarly showed that the children had significantly better performance on computation items involving addition than each of the other four categories of computation items ($p < .01$ in each case). Also, the children had significantly larger mean score on computation items involving subtraction than those involving multiplication, division, or mixed operations ($p < .01$ in each case). In contrast, the mean scores on multiplication items, division items, and items that involved mixed operations were not significantly different from each other.

Table 3. Means and Standard Deviations of Scores on Concepts Items

Classification of Concepts Items	Number of Items	Mean	Standard Deviation
Concepts: Fractions/Decimals	5	0.31	0.48
Concepts: Principles/Rules	5	1.62	0.77
Concepts: Units/Measurement	5	0.85	1.14

Table 4. Means and Standard Deviations of Word Problem Scores

Word Problem Items by Operation	Number of Items	Mean	Standard Deviation
Word Problem: Addition	3	0.92	0.64
Word Problem: Subtraction	3	0.69	0.63
Word Problem: Multiplication	3	0.54	0.66
Word Problem: Division	3	0.69	0.63
Word Problem: Mixed Operations	3	0.69	0.63

Performance on Items that Tap Mathematical Concepts

The items included in the mathematical concepts subtest were classified into three categories each containing five items: concepts of fractions or decimals, concepts involving principles or rules and concepts pertaining to units/measurement. The mean scores for the three categories are shown in **Table 3**. The data clearly show that the children's performance on all three categories of mathematics conceptual items was far below the 50% correct cut-off score. That is, compared to the 50% correct cut-off score (that is, a score of 2.5 out of 5), the children had significantly lower mean score on fraction/decimal items ($t = -16.45$, $df = 12$, $p < .001$), on items that involved rules/principles ($t = -4.15$, $df = 12$, $p < .01$), and on items that involved units/measurement ($t = -5.22$, $df = 12$, $p < .001$).

Thus, unlike their performance on computation items, the children performed poorly (that is, far below the cut-off score) on all three categories of conceptual items. However, paired-samples t-test showed that the children's mean score on conceptual items involving principles or rules was significantly better than their mean score on items involving fractions or decimals ($t = 4.98$, $df = 12$, $p < .001$) but not on measurement items ($t = 1.87$, $df = 12$, $p > .05$). Also, the children's mean scores on fraction items and measurement items were not significantly different ($t = -1.72$, $df = 12$, $p > .05$).

Performance on Word Problem Items

Like the computation subtest, the items of the word problem subtest were classified into five categories involving the four arithmetic operations and mixed operations. The resulting mean scores are presented in **Table 4**. Compared to the 50% correct cut-off score (that is, a score of 1.5 out of 3), the children's mean scores for all five categories were significantly lower ($p < .01$ in each case).

A further analysis of the data using paired-samples t-test showed that the mean scores did not show any statistically significant difference when compared pair-wise ($p > .05$ in each case). Overall, the children's mean scores on all five categories of word problem items were more or less comparable but significantly lower than the criterion score.

DISCUSSION

The importance of error analysis as an effective method in providing more detailed information about learners' errors has been well documented (see Kingsdorf & Krawec, 2014). More importantly, error analysis provides important information for teaching as well as intervention that aims to improve children's performance on a number of mathematical areas. Further, several researchers (e.g., Herholdt & Sapire, 2014) point out that error analysis provides a learning opportunity to teachers to improve their mathematics teaching and this holds not only for children with MD but also for the general student population.

The purpose of this study was to examine the errors committed by 13 sixth grade children with MD on a mathematics test comprising three subtests: computations, concepts and word problems. In an effort to obtain a clearer picture of the children's errors, each subtest was further divided into more homogeneous sets of items.

Overall, the results indicated that the children's performance on the test was substantially lower than the 50% correct cut-off score showing that the children committed a large number of errors. More specifically and in response to the research questions, the study yielded the following results. The children did not perform equally well on the five categories of the computation subtest. They performed well above and slightly above the 50% correct cut-off score on computation items involving addition and subtraction, respectively. But they scored significantly below the cut-off score on the remaining three categories (multiplication, division and mixed operations).

- The children performed substantially below the cut-off score on all three categories of the mathematical concepts items. However, they performed relatively better on concepts involving principles/rules and relatively poorly on fraction/decimal concepts. The children performed consistently and significantly below the cut-off score on all five categories of word problem items (addition, subtraction, multiplication, division and mixed operations).
- The children performed substantially below the cut-off score on all three categories of the mathematical concepts items. However, they performed relatively better on concepts involving principles/rules and relatively poorly on fraction/decimal concepts.
- The children performed consistently and significantly below the cut-off score on all five categories of word problem items (addition, subtraction, multiplication, division and mixed operations).

Previous research generally indicated that children with MD perform better on computation items than on other mathematics subtests notably word problems (e.g., Jordan & Montani, 1997; Ostad, 1998). However, while such a conclusion is generally true, it is misleading because the children's performance was not equally good on all types of computation items. Thus, to draw more accurate conclusion, the findings of this study underscored the importance of examining the children's performance on tests that focus on more homogeneous or specific mathematics tasks (that is, by going beyond the often used general categories such as computations and word problems).

Overall, the children performed satisfactorily on two categories of the computation subtest, namely computation items involving addition (mean = 75% correct) and subtraction (mean = 52% correct). In direct contrast, by far the worst level of performance the children displayed was in mathematical concepts that involved fractions/decimals. While this result is in agreement with findings of some previous research (see Montani, 2003), it suggests that problems pertaining to mathematical concepts are even more difficult than word problems. That is, even though word problems are generally considered more difficult than computations, according to the results of this study, items on mathematical concepts involving fractions or decimals are even more difficult for children with MD. Previous research has also shown, with at-risk (for MD) children (e.g., Malone & Fuchs, 2017) and with children who have MD (Hecht & Vagi, 2010), that problems involving fractions present persistent and significant difficulty for elementary school children.

CONCLUSION

The above findings show that the children with MD performed significantly lower than the 50% correct criterion on all mathematical tasks except computation items that require the application of addition and subtraction. Even addition and subtraction were found to be difficult for the children when the items are presented in the form of word problems suggesting that the children have problems converting the word problems into equations which can lead them to the solutions. The children's performance was the lowest on items of mathematical concepts pertaining to decimals/fractions.

Implications for Classroom Instruction

The results of this study have several implications for classroom instruction. The main implications are described below.

1. Mathematics has been taught for a long time as rote application of basic skills without giving attention to strategy instruction. Intervention research focusing on mathematical problem solving has provided evidence that children who lack problem solving strategies need explicit instruction to facilitate, among

others, their understanding, executing and evaluation of the problems (see Ostad, 1999). Thus, children need to be taught what strategies are available to solve one kind of mathematical problem or another and how to use the strategies. Besides, to minimize difficulties the children may face as well as to give life to the problems, selecting concrete tasks from the children's daily life experiences would be of considerable help.

2. The results of this study indicated that the children with MD displayed the poorest level of performance on the mathematics concepts subtest. Experience and observations indicate that in Ethiopian primary schools, mathematics teaching tends to focus more on rote memorization than understanding, on knowledge of computational procedures than on knowledge of concepts and problem solving skills. The results also seem to highlight this trend. On the other hand, there is evidence to support that children who better understand concepts also tended to solve problems better in several mathematical domains (Rittle-Johnson & Siegler, 1998) suggesting that the focus in teaching mathematics should center on mathematical concepts. It would seem logical to assume that if children have consolidated knowledge of mathematical concepts, then they would encounter difficulties relatively rarely. Accordingly, teachers of children with MD should exert every possible effort to provide explicit instruction on mathematical concepts.

3. Comparison of the children's mean scores on the computation and word problem subtests indicate that even though the same operations were involved in both subtests, the children performed relatively better on the computations subtest. This implies that word problems present additional difficulties to the children and perhaps this has something to do with the children's difficulty in understanding the problem and the procedures necessary to convert the word problem to a mathematical equation with an unknown (or variable). If this is a valid assumption, then teaching should focus on encouraging children to follow some specific procedural steps to solve the problem accurately. First teaching the procedures and then encouraging the children to exercise them by themselves in solving word problems and finally providing feedback on their work are important steps that should be taken to support the children in class.

4. The time that would be spent in supporting children with MD need to be used wisely taking into account the children's relative difficulties. That is, more time should be allotted for difficult problems such as multiplication and division rather than addition and subtraction. Similarly, more time should be spent in teaching fractions/decimals and how problems involving fractions are solved than teaching mathematical rules/principles.

Limitation of the Study

One limitation of the present study is the small number of children (n = 13) with MD who participated in the study. Although children with MD are generally small in number compared to typically achieving children, readers should generalize the results cautiously for the sample size is very small to detect all mathematical errors that children with MD could commit.

A second limitation of the study arises from its cross-sectional nature. The children with MD who participated in this study were also from one grade level (Grade 6) only. For these two reasons, it is difficult to ascertain whether the patterns of mathematical errors observed in this study have emerged in earlier grades or typically characterize children with MD at the sixth grade level.

REFERENCES

Badian, N. A. (1999). Persistent arithmetic, reading, or arithmetic and reading disability. *Annals of Dyslexia, 49*, 45-70. https://doi.org/10.1007/s11881-999-0019-8

Brown, L., Sherbenou, R. J., & Johnsen, S. K. (1997). *Test of nonverbal intelligence: A language-free measure of cognitive ability* (3rd ed.). Austin, TX: Pro-Ed.

Cawley, J. F., & Miller, J. H. (1989). Cross-sectional comparisons of the mathematical performance of children with learning disabilities: Are we on the right track toward comprehensive programming? *Journal of Learning Disabilities, 22*(4), 250-254, 259. https://doi.org/10.1177/002221948902200409

Fleischner, J. E., Garnett, K., & Shepherd, M. J. (1982). Proficiency in arithmetic basic fact computation of learning disabled and nondisabled children. *Focus on Learning Problems in Mathematics, 4*(2), 47-56.

Geary, D. C., Hamson, C. O., & Hoard, M. K. (2000). Numerical and arithmetical cognition: A longitudinal study of process and concept deficits in children with learning disability. *Journal of Experimental Child Psychology, 77*(3), 236-263. https://doi.org/10.1006/jecp.2000.2561

Hecht, S. A., & Vagi, K. J. (2010). Sources of group and individual differences in emerging fraction skills. *Journal of Educational Psychology*, *102*(4), 843-858. https://doi.org/10.1037/a0019824

Herholdt, R., & Sapire, I. (2014). An error analysis in the early grades mathematics – A learning opportunity? *South African Journal of Childhood Education*, *4*(1), 42-60. https://doi.org/10.4102/sajce.v4i1.46

Jordan, N. C., & Montani, T. O. (1997). Cognitive arithmetic and problem solving: A comparison of children with specific and general mathematics difficulties. *Journal of Learning Disabilities*, *30*(6), 624-634. https://doi.org/10.1177/002221949703000606

Kingsdorf, S., & Krawec, J. (2014). Error analysis of mathematical word problem solving across students with and without learning disabilities. *Learning Disabilities Research & Practice*, *29*(2), 66-74. https://doi.org/10.1111/ldrp.12029

Malone, A. S., & Fuchs, L. S. (2017). Error patterns in ordering fractions among at-risk fourth-grade students. *Journal of Learning Disabilities*, *50*(3), 337-352. https://doi.org/10.1177/0022219416629647

Miller, S. P., & Mercer, C. D. (1997). Educational aspects of mathematics disabilities. *Journal of Learning Disabilities, 30*(1), 47-56. https://doi.org/10.1177/002221949703000104

Montani, T. O. (2003, March). Mathematical disabilities in elementary school children. Paper presented at Oxford Round Table, Pembroke College.

Ostad, S. A. (1998). Developmental differences in solving simple arithmetic word problems and simple number-fact problems: A comparison of mathematically normal and mathematically disabled children. *Mathematical Cognition*, *4*(1), 1-19. https://doi.org/10.1080/135467998387389

Ostad, S. A. (1999). Developmental progression of subtraction strategies: A comparison of mathematically normal and mathematically disabled children. *European Journal of Special Needs Education*, *14*(1), 21-36. https://doi.org/10.1080/0885625990140103

Rittle-Johnson, B., & Siegler, R. S. (1998). The relation between conceptual and procedural knowledge in learning mathematics: A review. In C. Donlan (Ed.), *The development of mathematical skills* (pp. 75-110). Hove, UK: Psychology Press. https://doi.org/10.4324/9781315784755-6

Siegel, L. S., & Ryan, E. B. (1989). The development of working memory in normally achieving and subtypes of learning disabled children. *Child Development*, *60*(4), 973-980. https://doi.org/10.2307/1131037

Transitional Government of Ethiopia. (1994). *Education and training policy*. Ethiopia: EMMPDA.

Zeleke, S. (2001). Gender differences in mathematics performance in the elementary grades: Implications for women's participation in scientific and technical occupations. *Eastern Africa Social Science Research Review, 17*(2), 109-127.

Zeleke, S. (2004). *Children with mathematics difficulties: Some features of their cognitive and affective functioning* [Doctoral dissertation, University of Oslo]. Norway: Unipub As.

Zentall, S. S., & Ferkis, M. A. (1993). Mathematical problem solving for youth with ADHD, with and without learning disabilities. *Learning Disability Quarterly*, *16*(1), 6-18. https://doi.org/10.2307/1511156

Please cite: Teketel, S. Z. (2022). Analysis of Mathematical Errors Committed by Grade Six Children with Mathematics Difficulties: Implications for Classroom Instruction. *Journal of Research in Didactical Sciences*, *1*(1), 12500. https://doi.org/10.51853/jorids/12500

Received: 07 February 2022 ● Accepted: 28 August 2022

Journal of Research in Didactical Sciences
ISSN: 2997-5905 (Online)
VOL. 1, ISSUE 1, 2022
Article No: 12515

RESEARCH ARTICLE

OPEN ACCESS

Effects of Realistic Mathematics Education on Students' Academic Performance

Khurshida Nodirovna Patullayeva [1*]

[1] Suleyman Demirel University, Kazakhstan
* Corresponding author: khurshidapatullayeva@gmail.com

Abstract: This study presents a learning experiment characterized by a sequence of actions based on the use of realistic mathematical education in teaching mathematics. The purpose of this study is to investigate the difference in student performance in mathematics after the introduction of realistic mathematics education and traditional education. The research was conducted with 43 students attending the 7th grade of lyceum "Bilim-Innovation" for girls in the city of Shymkent in the fourth semester of the 2021-2022 academic year. According to the scores obtained from the pre-test at the beginning of experiment and the post-test made after the application, it is seen that the lesson taught according to the Realistic Mathematics Education (RME) approach is significantly more effective than the traditional teaching approach among the achievements of the experimental and control groups. This study also discusses the theoretical basis of the intervention and proposes theoretical reasons for choosing Realistic Mathematics Education theory.

Keywords: realistic mathematical education, progress in mathematics, mathematical education and teaching

INTRODUCTION

One of the educational goals is for students to grow in the personal, social and educational fields and acquire the necessary skills. Today, it is impossible to be unaffected by updated mathematics syllabuses, updated course syllabuses, and studies that can contribute to our knowledge of mathematics, and they are prepared with great interest and enthusiasm.

Mathematics has a scientific common sense that follows a completely unique order. Mathematics, which we come across at each level of our formal training life, beginning from number from school and finishing at university, is likewise essential in our real life. In addition, mathematics additionally serves as a device for studying different branches of science (Laurens et al., 2017). Regarding the improvement of mathematics James and Ioan (2002) say that "Today, mathematics is greater exciting due to its effect on enterprise and social sciences. As new troubles arise, new techniques are needed", he talks this improvement process.

A researcher who defined knowledge of mathematics as "a conceptual system that can use the usual tools of human intelligence in an unusual way" states that "It was emphasized that the relationship between the real world and mathematics should not be ignored" (Livio, 2011). "The world of mathematics is nothing more than a reflection of real life in our minds. This is where every discovery about the world of mathematics gives us information about the real world. It is clear to give" (Rényi, 2006).

Given the evolution of mathematics and today's innovations, we need to contribute to the advancement of research in this direction, to our knowledge of math, and to show a match between our knowledge of the real world and our knowledge of mathematics.

The aim of mathematics education is to be critical of all kinds of problems by acquiring knowledge and skills that help individuals evaluate problems they may encounter in their real lives, inferring thoughts and connecting mathematics. It is to help you reflect. Concepts and operations used for execution (Altun, 2002). Students have a negative attitude towards mathematics because they find mathematics lessons difficult and fear they will not succeed in these lessons. Linking mathematics to real life will prevent such privative situations, increase success, and establish a positive attitude towards mathematics (Parveva et al., 2011).

Developed by the Organization for Economic Cooperation and Development (OECD) in 1997, the International Student Assessment Program (PISA) has been conducted every three years since 2000 and is applied internationally to assess student achievement levels of 15 years old students. The app evaluation areas are mathematics, science, and reading (Woodward, 2009). Despite the significant changes made to the educational approach in Kazakhstan, it appears that we have not been able to achieve the desired levels in the results of the international student assessment program (Mailybaeva et al., 2018).

The methodological instruction letter "On the specifics of the organization of the educational process in secondary schools of the Republic of Kazakhstan in the school year 2021-2022" (Letter, 2021) uses mathematical knowledge, skills, calculations, measurements, and graphic abilities acquired by students in order to improve basic mathematical knowledge in teaching "algebra", forming "geometry" are recommended to teach the skills necessary to solve practical tasks. Realistic mathematics education (RME) is also based on practical problem solving, starting with real problems as well as real contexts that demand mathematical abilities in many mathematical subjects questions of the International Assessment program (Mailybaeva et al., 2018).

The relevance of the work is the target of the Ministry of Education and Science of the Republic of Kazakhstan of the National Academy of Education (2021), to solve the problems identified according to the assignments of teaching math, algebra, geometry, orientation of knowledge of the students on mathematics modeling and the interpretation of mathematics patterns that declare real processes.

The aim of the study is to determine the influence of RME-based educational activities bounded with real life setups on students' academic achievement. Given that mathematics is an abstract subject and the need to understand the results achieved by the student, the goal of the study will be better expressed.

The research hypothesis: The use of a realistic method of teaching mathematics in the teaching of school mathematics programs will have a positive impact on the academic performance of students.

THEORETICAL BACKGROUND

In this chapter, interpretations and estimations have been provided focusing on mathematics and didactics of mathematics and RME. Example studies in the (inter) national literature were also discussed, which will provide a scientific source and input to the research and whose outcomes have been assessed.

What is Mathematics?

The responses to the question did not provide a complete definition, and there was no consistency in the definitions made to date. The main reasons given for this have been "the choice of sources for organizing science, the distinctions in the aims of teaching mathematics, and the different qualities in understanding of those involved in arithmetic at slightly different levels" (Altun, 1989, p. 183). About mathematics, he said: "In the 21st century, mathematics is a huge and varied subject. It encompasses such a wide range of activities that it is impossible to summarize all its facets under a single name" (Crilly, 2013, p. 9). Although Frenkel (2013) said, "Mathematics could be a way to reality and understand how the world works. It could be a common idiom that has become the gold norm of truth" (p. 16).

Mathematics Education

Teaching and training in mathematics is an activity that poses great challenges all over the world. Further, the mathematics instruction necessary to fulfill its purpose must be corresponding to the level of the students and not presented in a top-down fashion. At the end of a process that requires them to learn or feel the way they are, students escape from mathematics or turn into robots that process quickly and learn to check off one of four or five versions (Torun, 2015).

As for teachers, irreplaceable for teaching mathematics: "In the event that mathematics does not suppress the substitutes; in case it is taught by a teacher who is instructive, creates himself, can reflect his curiosity and education, and gets the subject in great detail, it is easy to have control over the pickups" (King, 2006). Also, looking at educational problems from a different perspective, Khurgin (1974) said: "I notice that the students in the school appreciate their teachers, not the subjects. Indeed, countless students are quick to ignore the only mathematics subjects they are intended for. What they keep in mind are some hypotheses that give them brain pain, some unclear images, interesting or emotional events …"

Realistic Mathematics Education (RME)

Before passing on to RME, it is utility to remember the statement: "We can understand nature only if we study the language and the signs it speaks to us, this language is mathematics and the symbols used are mathematical signs" (King, 2006). Understanding of nature, in 2013, once again underlined the need to learn this language, stating that "Mathematics teaches us to meticulously analyze reality, examine facts and follow them wherever they conduct" (Frenkel, 2013).

In describing RME, Hersh and John-Steiner (2010) use the phrase "One of the pains to number sensibility, mental mathematics and understanding of mathematical template children is RME, which was begun in the Netherlands by the famous mathematician Hans Freudenthal". Summarizing the life of the mathematician Freudenthal, who made productive endowments to the mathematics history, they said: "He is credited with single-handedly sparing the Netherlands scientific extension untapped in the world. Today, at least 75% of Dutch primary schools use RME-based reading materials" (Hersh & John-Steiner, 2010, p. 326).

Hans Freudenthal became a professor of applied mathematics at the University of Utrecht after emigrating from Germany to the Netherlands. Succeeding the Wiscobas project evolved in the Netherlands in 1968, an Institute for the Development of Math Education was established at Utrecht University in 1977, a real step forward. In September 1991 this institute was called the Freudenthal Institute (Hersh & John-Steiner, 2010). RME is a field-specific educational treatment and speculation to teaching mathematics, encompassing Freudenthal's views on math, first created and injected by this Freudenthal Institute in the 1970s.

By Zulkardi (2000), there are two important rules in RME:

1. Mathematics must be united to reality.
2. Mathematics is a human activity.

Some Studies on the RME Approach

In the study by Zulkardi et al. (2002), there is a four-year project study hold on the introduction of RME among 27 future mathematics teachers in India. In the completed project, there are explanations of the main features of RME, how teaching is carried out according to the RME approach, what kind of material should be used and how assessment should be carried out in an adapted lesson design to this approach. As a result of the work, it was established that RME positively influences the behavior of student teachers, that student teachers better understand the relations between theoretical knowledge and practice and that the milieu during the learning phase has a positive effect.

Indonesian researcher Fauzan (2002), in his study, tries to explain efficiency of RME approach for solving some mathematical problems in teaching. As part of the study, Indonesian primary school students took a ten-hour training course on "area and volume". Data was collected through observation, journal entries and interviews. When the findings were reviewed, it was stated that the RME method had a more positive effect on the training process. Students indicated they appreciate the RME method and have experienced positive changes towards the mathematics course.

Kwon (2009) studied the influence of RME-assisted education on growing achievement in teaching differential equations with 43 students at Ewha Women's University. Control and experimental groups were formed in the study and one group used a traditional method and the other group applied the RME-supported method. In the auditorium where RME assisted teaching took place, the student's thoughts and symbols were used in teaching the unit. When the data was analyzed, it was seen that the group to which RME-supported education was applied scored higher. Consequently, it was concluded that RME-supported education will bring another area to the teaching of differential equations and that this method can promote to the success of undergraduate students and their mathematics education (Kwon, 2009).

Bildircin (2012), in his study examined the impact of teaching the concepts of "length, area, and volume" according to the RME Education approach on the attitudes and performance of students towards math. For the quantitative part of the study, the sample consisted of 19 experimental groups and 18 control groups of 37 fifth-graders. As data collection tools, a mathematics achievement test (AT) to see student achievement, an attitude scale, and a student opinion sheet consisting of open-ended questions have been used in research to determine students' opinions of the RME approach. Research has found that teaching with activities prepared according to RME is more effective than traditional teaching when it comes to teaching the frames "length, area, and volume". However, considerable distinction was not found between two groups in students' attitude towards (Bildircin, 2012).

An examine posted by way of Kaylak (2014) applied RME approach to 7th grade students as a part of the discover areas of quadrilaterals module and tested the impact of this learning on students' success and mathematics potential. A total of 55 students took element in the look at, 28 of them in the experimental group and 27 in the control group. The success take a look at, which consisted of 12 questions, became used because the very last take a look at. In addition, earlier than and after education, a degree of ability in mathematics was used to determine the mathematics indicative attitudes of each group. At the same time as the members of the experimental group had been divided into groups in line with the precept of cooperation of the RME, deliberating that the students in the control group had degrees of interest and fulfillment. As a result, it became determined that the activity of finding the areas of quadrilaterals organized in accordance with the is effective in attaining student's fulfillment than conventional methods. However, whilst considering the mathematics attitudes of students, it became clear that there was no big distinction among the experimental and control groups (Kaylak, 2014).

Kasymova and Tashetov (2017) in their article proposed a technique of solving troubles in chances in college mathematics. They stated that further to fixing issues encountered within the auditorium, it's far beneficial to prepare an extracurricular course. This route is designed for one group every two weeks (Kasymova & Tashetov, 2017). The organization includes 7th grade students who need to have a look at mathematics for 3 years. In conclusion, the authors reviewed the problem of teaching the topic of "Interest" in excessive college and cited the sensible cost of the trouble of chances utilized in diverse fields of technological know-how and in real existence. Their concept is to layout the teaching method in that field it promotes the level of knowledge, abilities and skills important for students to be successful not most effective in arithmetic but also in other topics.

Basic Principles of Realistic Mathematics Education

In the scope of the basic principles of RME, King (2006) states that "It's essential to find troubles that are not only new, however additionally vital, and to study mathematical strategies to solve those problems; in any other case it may be created". Hersh and John-Steiner (2010), then again, kingdom of the students who are delivered to the brand new RME technique: "The belief of why they take a look at mathematics deepens children's intellectual capabilities. Mathematical instructions, which they name calculations, have to not be the primary intention. Either, a sturdy child who learns to suppose without remembering or ignoring numbers."

RME's basic principles are divided into several types in deal sources. van den Heuvel-Panhuizen (2003) tested the principles of the in six sections. The six primary ideas mentioned are explained in detail in this phase.

Activity principle: A pastime procedure in which the student himself is concerned is one of the most main methods of learning a mathematical idea. According to this precept, individuals must actively participate within

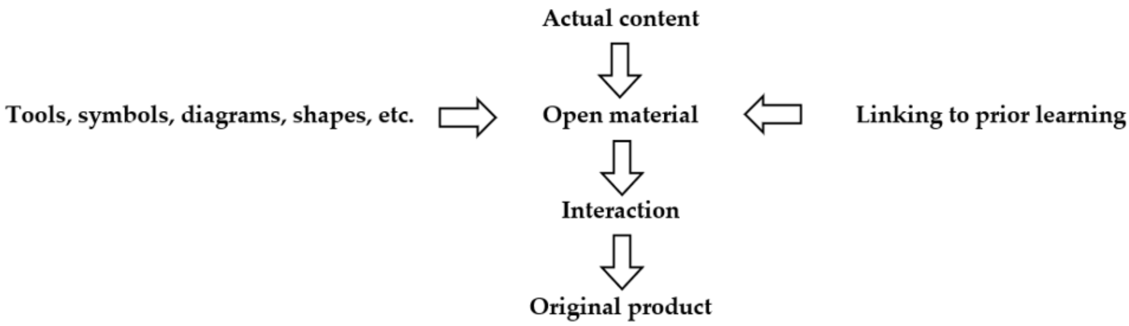

Figure 1. Model of preparation of course materials in RME (Zulkardi, 2002)

the education technique without the use of the geared-up expertise and understand that they're an energetic mastering member who develops all forms of mathematical tools, their own products and effective ideas (Kurt, 2015).

Reality principle: It needs to be ensured that students use their own knowledge, experience and equipment and comprehend that they need to learn mathematics due to the fact it's far useful. As opposed to beginning with sure abstractions or definitions, mathematics coaching needs to be began with wealthy mathematical situations so that forgetting will not be brief (Uygur, 2012). The student ought to be able to see mathematics as beneficial, beneficial and helpful as feasible.

Level principle: In this principle, the need of discovering the competencies pondered in the activities carried out, being able to reflect on consideration on the sports executed, growing strategies and achieving from one level to the next with interplay is emphasized (Kaylak, 2014).

Principle of interrelationship: It is far from a fact that the achievements and subjects of the arithmetic course progress in concord with every other, indivisible and cumulative manner. In step with this principle, the realization that mathematics getting to know departments are not separated from every different, that a large attitude is required, and that the achievements are essentially interrelated (Bildircin, 2012). For example, so as for college kids to expect the dimensions of the flag, they should have not simplest measurement, but also content and concepts including ratio-proportionality, houses of the circle, geometry, and similarity.

Interaction (cooperation) principle: Teaching and learning process is a social activity. in keeping with this precept, students have to be supplied the possibility to proportion their know-how, strategies and innovations with every different. Consequently, students may be together in study room corporations, percentage and check their discoveries, think differently with the aid of seeing the techniques and solutions of others, and pass ahead of their own way instead of following the identical path (Cansiz, 2015).

Guidance principle: In teaching mathematics students need to rediscover arithmetic and direct the gaining knowledge of technique under the guidance of the teacher. According to Freudenthal (1991), that allows you to increase the effectiveness of guidance, the programs have to have chances suitable for the preferred goals, content richness need to be created and getting to know environments have to furnished, which can offer students with different perspectives that could manual them (Memnun, 2011).

Lesson Design in Realistic Mathematics Education

There was developed course designs of a few researchers in appliance with the RME approach with the aid of the use of three stages of shape (van den Heuvel-Panhuizen, 1996; Zulkardi, 2002).

Grade level: In this level, the instructions are prepared in step with all of the features of RME. In direction layout and inside the mastering manner, students ought to be "endorsed to supply mathematical tools consisting of symbols, diagrams, drawings, situations, and conceptual models; the students should receive the feasibility to have interaction as an energetic participator and in affirm with the standards of RME for the duration of the technique" states the importance of sophistication stage (Streefland, 1990). On this manner, it is aimed that the student will be capable to provide independently and discover their very own studying ways. There is developed a model for the instruction of RME course materials shown in **Figure 1** (Zulkardi, 2002).

Table 1. Percentages and interest achievement test specification table

Subjects	Gains	Number of Questions
Percentage calculations	Explain relationships between fractions and percentages	1, 2, 6, 16
	Calculates percentages used in shopping and commerce	3, 4, 7, 8, 9, 12, 15, 17, 18, 19
Interest calculations	Makes simple interest calculations	5, 10, 11, 13, 14, 20

When **Figure 1** is examined, the application order of Zulkardi (2002) in designing a lesson may be seen in precis form. it's miles viable to explicit this order as follows:

1) A real place to begin is adapted to the material at hand,
2) Hyperlinks are established among clues and beyond learning,
3) Students produce new fashions as a collection in the light of the available facts, and
4) During the course, students are provided to socialize with each other, talk, and paintings collectively.

Lesson level: This stage, which is likewise utilized inside the feel of popular degree, focuses on horizontal mathematization. Cansiz (2015) said that "A constrained variety of locally produced substances are applied to put in force the real line and keep it in existence." The students may be supplied with their personal fashions by way of assisting the materials with one-of-a-kind and unique materials at the theoretical stage.

Theoretical level: While horizontal mathematization is attempted to be found out at the elegance and path degree, the focus on the theoretical level is "vertical mathematization". All activities at the previous degrees, along with development and layout, educational discussions, and exercise within the lecture room, are appropriate materials for this degree (Gozkaya, 2015). As a result, preferred acquisitions and definitions are achieved via symbolizing impartial of materials. Further, a transition to a summary environment is finished via an actual-lifestyles physical model.

METHODS

In this study, a full design with pretest-posttest, that is one of the quantitative techniques of research, was used. Experimental research is a suitable studies layout for reason and effect (Balci, 2011). However, it is accurately desired as opposed to plastic in instructional materials.

Working Group

The pattern of the studies is the 7th grade students in the City of Shymkent. The experiment became performed with a complete of 48 college students within the 7A with 22 students and the 7B with 21 college students. Class 7A became chosen as experimental group and 7B as the control group.

Data Collection Tools

As a collection tool, the Achievement Test (AT) associated with percentage and interest, prepared by the researcher. Further, worksheets and activities have been developed by researcher to be used within the experimental group concerning the 7th grade percent and interest subject. Similarly, the opinion form prepared by Ersoy (2013) became applied to determine the evaluations of the experimental group students approximately RME.

Achievement Test

At the first stage, the researcher prepared 30 AT questions. A pilot application of a AT was applied to 65 8th grade students studying at a secondary school in Turkestan. As a result of the analysis, 10 questions were removed and an AT of 20 questions was obtained. Three mathematics teachers were consulted to ensure the validity of the content. After that, the necessary measures were taken and an AT of 20 questions was created. An AT specification table (**Table 1**) was prepared.

After the application, items with an item-total correlation of 0.30 and more are well-distinguished by students, items between 0.20-0.30 can be usen in the test if it is deemed necessary, or the item should be corrected, and items with a lower than 0.20 will not be used in the test (DiBattista & Kurzawa, 2011). It was revealed that it is manifested

Table 2. Percentages and outcomes of achievement test item analysis for the subject of interest

Item No	Item Total Correlation	(Under 27% – Upper 27%)
Q1	0.208	2.894
Q4	0.233	3.631
Q5	0.381	5.899
Q8	0.389	6.159
Q9	0.356	5.749
Q10	0.343	7.370
Q11	0.324	4.051
Q12	0.354	5.365
Q14	0.341	6.844
Q15	0.220	2.802
Q16	0.544	8.951
Q18	0.389	7.895
Q19	0.313	5.370
Q20	0.298	4.782
Q21	0.425	7.823
Q22	0.310	4.508
Q24	0.464	7.844
Q25	0.298	4.508
Q27	0.221	3.522
Q28	0.474	7.522

by a t-test between diseases and often occurs between diseases by 27%. With the common element of date and t-test, **Table 2** is in this application list.

By the results of the analysis of items, since the item 2, 3, 6, 7, 13, 17, 23, 26, 29, and 30 questions' discrimination index was less than 0.200, and researcher decided to exclude these questions from the test. Since the index of discrimination of questions 1, 4, 15, 20, 25, and 27 are in the range from 0.2 to 0.3, these questions were mended and comprised in the test. Since the discrimination indices for the other 14 questions were above 0.3, these items were left native in the test. As a result of statistics, KR-20 turned out to be equal to 0.762. Thus, the 7th grade percentage and interest AT, consisting of 20 questions, has acquired its final form.

Mathematics Worksheets

There have been prepared worksheets for experimental group to recognize the situation and clear up in the lesson. Eight worksheets were prepared and five of them related to the percentages, whilst others associated with the interests. Worksheets consist of the troubles associated with real life, that are student solving these troubles can believe wherein to use mathematical expertise. When appearing tasks, the trainer simplest directs the scholars and the students determine on their own. Once they had questions that they had the opportunity to speak about with friends.

Activities

Also, prepared activities for experimental group to apprehend the topic vs. From the six activities, four of them have been prepared with regards to percentage and others had been organized with reference to interest. For the duration of the implementation of the activities, the instructor only guided the students. It is aimed that scholars find a positive method or their personal answers as a result of activities. whilst the activity was finished, the children have been requested whether there has been a well-known solution approach and the solutions had been discussed.

Mathematics Opinion Form

To the experimental group students, a five-item opinion form developed by Ersoy (2013) was utilized, to decide the students' evaluations about the effectiveness of RME method. Within the opinion form, it became asked what their notion about the RME method, whether they preferred the usage of the approach and the reasons for this. In addition, it turned into attempted to accumulate information about the advantages of the method, whether or not the students need to educate once more with this technique.

Data Collection Process

After establishing the experimental group and control groups, AT was used as a pre-test on these groups. The 7A and 7B classes at Shymkent's "Bilim-Innovation" lyceum for girls were notified about the research before it began. The experimental group received RME-supported instruction, while the control group received conventional training. Daily life issues were used to introduce material to the experimental group. Each of these issues represented a genuine challenge for the learner. Definitions, background knowledge, and sample analyses were all included in the instruction given to the control group. The definitions and background knowledge on the topic were found by themselves of students during the RME-supported instruction. The pre-test was administered to the groups in the beginning of research. The first group-working classes were held on April 1. Throughout the course of the study, the lessons were delivered to the control group using the standard teaching methodology. The RME-supported teaching methodology was used to deliver the lessons to the experimental group. The experimental group used lesson plans created in accordance with RME, and the researcher himself delivered the lessons in both groups. In the experimental group, four to five students were divided into groups after first learning about RME.

Real-world issues are introduced to the pupils at the start of the class by writing them on the board. Students were divided into groups and instructed to solve issues collaboratively. The pupils were given enough time at this point to ponder, solve difficulties, work together, and understand the scenarios that will be presented in the tasks.

Students were invited to pose related problems as a second phase. The challenges the students generated were presented to their peers in class during a discussion, which allowed everyone to come up with solutions.

Worksheets created for each of the themes in the percentage and interest unit were given to the students in the third stage. With the worksheets, the students began to work through the issues by focusing on the subject's ideas. Since there was no rivalry between the groups, the students who figured out the challenges first aided their own friends in the group before assisting their friends in the other groups who required assistance. The lecture began with definitions of the topic in the control group. The teacher then answered the practice problems, and the solutions were then posted on the board for the pupils to solve. The following topic was introduced when the teacher and the pupils had satisfactorily solved the sample questions. The subjects were covered using the textbook in the control group. Both groups received education for four weeks.

Analysis of Data

The study used the SPSS package program to examine the data obtained from the accomplishment test and the attitude test. The analysis employed two separate tests. The variable we are interested in is virtually not bell-shaped. This is frequently referred to as not normally distributed in statistics. Consequently, Mann-Whitney U-test and Wilcoxon signed-rank test were applied to the analysis in this study.

Mann Whitney U-significance test's level was set at $p < 0.05$, while Wilcoxon signed-rank test's significance level was set at $p < 0.01$. KR-20 reliability coefficient was investigated for the accomplishment test reliability.

The experimental group of students were given an opinion form after the application and were then surveyed using the RME method to get their opinions on the topics of percentage and interest. Following the gathering of the opinion forms from the students, the responses each student provided to the form's five questions were reviewed. Following that, these responses were separated into positive and negative categories, and their quality was assessed by using examples from the mostly student-provided responses.

RESULTS

Alignment of Working Group

After randomly assigned to experimental and control group students, their pre-test scores on achievement and attitude were compared to see if the two groups were comparable. As a pre-test before to the application, the AT was administered to the experimental group and the control group, and the students' pre-test results were analyzed using Mann Whitney U-test. **Table 3** provides the outcomes that were attained. The mean rank of the students in the experimental group was 21.00, while the mean rank of the students in the control group was 23.05, according to **Table 3**. It appears that there is no statistically significant difference between the groups ($p > 0.05$). Based on this finding, it may be concluded that the two groups were equally successful prior to the experimental process.

Table 3. Mann Whitney U-test results regarding pre-test achievement scores of groups

Groups	n	Rank Average	Rank Sum	U	p
Experimental	22	21.00	463.00	208.00	0.589
Control	21	23.05	485.00		

Table 4. Wilcoxon signed-rank test results regarding the pre-test and post-test achievement scores of the experimental group

Post-/Pre-Test	n	Rank Average	Rank Sum	Z	p
Negative Rank	0	0.00	0.00	-4.126	0.000
Positive Rank	22	11.60	254.00		
Equal	0				

Table 5. Wilcoxon signed-rank test results regarding the pre-test and post-test achievement scores of the control group

Post-/Pre-Test	n	Rank Average	Rank Sum	Z	p
Negative Rank	4	7.14	28.60	-2.479	0.014
Positive Rank	14	10.19	143.50		
Equal	3				

Table 6. Mann Whitney U-test results regarding the post-test achievement scores of the groups

Groups	n	Rank Average	Rank Sum	U	p
Experimental	22	26.24	578.00	139.00	0.024
Control	21	17.58	368.00		

Findings Related to Achievement Test

The groups' pre- and post-test results were compared once application was complete, and differences were looked at. The results of the pre- and post-test of the groups were used to conduct Wilcoxon signed-rank test for this purpose. **Table 4** contains the results of Wilcoxon signed-rank test utilizing the pre-and post-test scores of the students in the experimental group.

After the application, pre- and post-test scores of the students in the experimental group are substantially different ($p < 0.01$), according to an analysis of **Table 4**. It is obvious that the difference favors the positive rankings, or the post-test score, when the mean rank and sums of the difference scores are considered.

Wilcoxon signed-rank test was run to see whether the differences between the control group's pupils' pre-and post-test results were meaningful. **Table 5** provides the outcomes that were attained.

Analysis of **Table 5** reveals that the difference between the test results of the control group students before and after the application is statistically significant ($p < 0.05$).

The question: "Was there a significant difference between the post-test scores of the students in the experimental and control groups?", was finally answered using Mann Whitney U test. **Table 6** provides the outcomes that were attained.

Table 6 shows that the experimental group's mean rank was 26.24, whereas the control group's mean rank was 17.58. It was discovered that there was a statistically significant difference between these two groups ($p < 0.05$). The group in which RME was applied had greater accomplishment scores than the group in which RME was not applied, as shown by the mean rank.

Findings on Attitude Test

The findings of the pre- and post-test for two groups were compared once the application was complete to see whether there had been any changes. With respect to the results of the pre- and post-tests for each group, Wilcoxon signed-rank test was used. **Table 7** contains Wilcoxon signed-rank test findings.

Table 7. Wilcoxon signed-rank test results regarding the pre-test and post-test attitude scores of the experimental group

Post-/Pre-Test	n	Rank Average	Rank Sum	Z	p
Negative Rank	6	7.59	45.60	-2.632	0.009
Positive Rank	16	12.98	208.50		
Equal	0				

Table 8. Wilcoxon signed-rank test results regarding the pre-test and post-test attitude scores of the control group

Post-/Pre-Test	n	Rank Average	Rank Sum	Z	p
Negative Rank	11	9.19	103.00	-0.676	0.498
Positive Rank	7	10.00	70.00		
Equal	3				

Table 9. Mann Whitney U-test results regarding the post-test attitude scores of two groups

Groups	n	Rank Average	Rank Sum	U	p
Experimental	22	27.83	613.00	104.00	0.002
Control	21	15.80	335.00		

Analysis of **Table 7** reveals a significant difference between the experimental group students' pre- and post-test scores at the conclusion of the application ($p < 0.01$). It is clear that the observed difference is in favor of the positive rankings, or the post-test score, when the mean rank and sums of the difference scores are examined.

The significance of the changes in the pre- and post-test scores of the students in the control group was evaluated using Wilcoxon signed-rank test. **Table 8** provides the outcomes that were attained.

Analysis of **Table 8** reveals that there is no statistically significant change between the pre- and post-test scores of the control group students following the application ($p > 0.01$).

When the application was complete, Mann Whitney U-test was used to determine whether there was a significant difference in the post-test scores of the students of the groups. The outcomes are displayed in **Table 9**.

When **Table 9** is studied, it is seen that the experimental group's mean rank is 27.83, whereas the control group's mean rank is 15.80. It was determined that there was a statistically significant difference between the groups ($p < 0.050$). The group in which RME was administered had higher attitude ratings toward mathematics than the group in which RME was not applied, it became obvious from the analysis of the mean rank.

Information Gleaned from Opinion Form

The data received from the opinion form were analyzed by dividing them into positive and negative categories for each question.

Student opinion on the first question: What are your views on realistic mathematics education?

<u>Positive answers</u>

It is excellent since it facilitates our daily lives. The questions now have much more fun. As a group, I believe it's much better.

I enjoy the class and don't grow tired with it as a result.

Friends of ours who had never been to class joined the group and took a seat at the board. It seemed like a lot of fun.

Before, I couldn't grasp mathematics, but now I can.

I began studying more since it was so detailed. I increased my standing up.

It will probably be necessary in our day-to-day lives.

<u>Negative answers</u>

When some buddies created noise, it was difficult for me to comprehend, but it was fantastic because I had fun.

When the replies are studied, it becomes apparent that the students' responses to the first question are favorable and that they have good opinions about RME. Many students reported that the majority of them found the lesson enjoyable and that this manner allowed even their friends who never attended lessons. Due to the distractions throughout the class, two students said they did not grasp portions of it.

Student opinion on the second question: Do you like teaching lessons with realistic mathematics education? Why?

Positive answers

Yes. I can better comprehend that method.

Yes. Because the group's knowledgeable friends assisted us when we were unable to find the answers to the questions.

I acquired a variety of problem-solving methods. I enjoyed myself while learning.

Yes. Because of the attendance of our friends who had never taken the class, I really enjoyed it.

Negative answers

The mathematics worked extremely well on occasion and poorly on sometimes. because I did not want to hang out with one girl in my group.

Analysis of the second question's responses shows that the majority of the responses are favorable. It is evident that a student who voiced disapproval grumbled about being in the same group as a buddy with whom he had previously had difficulties. The applied strategy is typically well-liked by the students, according on the replies offered when taken as a whole.

Student opinion on the third question: What are the benefits of RME supported teaching for you?

Positive answers

We avoid being taken advantage of when shopping thanks to it.

While shopping, I didn't comprehend the label discounts; now I do.

In a group, I comprehend things more clearly.

I go to a better lesson, where we learn with affection.

I seek friends advice on issues I don't comprehend.

Negative answers

The students did not share any unfavorable thoughts on this question.

Analysis of the third question's responses reveals that the participants were happy with the lesson's teaching strategy. Students claimed that using this strategy made mathematics easier to understand, more enjoyable, easier to apply to their daily lives.

Student opinion on the fourth question: Would you like to learn again with RME supported teaching method? Why?

Positive answers

Yes, I'd adore doing it. because learning is a lot of fun.

At first, I didn't like it, but later, I did.

Yes, I would since we don't even comprehend what happened in class.

A lot. With this approach, I began to comprehend more.

Negative answers

I would want to be in a different group.

No, since I'm not good at math.

When the responses were evaluated, it became apparent that most students desired to use this style once more, however some of them had unfavorable emotions for a variety of reasons. When the causes of these reactions were examined, it became clear that one student's dissatisfaction with his group was due to the presence of his friend in the group, and that some students were adversely affected by the noise during activities and in-group discussions and expressed negative thoughts.

Student opinion on the fifth question: How has your thoughts on mathematics changed after the training with RME?

Positive answers

I had always enjoyed math, and I began to love it even more.

I now find mathematics to be enjoyable.

My enthusiasm for mathematics grew.

I've stopped having stupid ideas. I feel comfortable with mathematics now. I'm confident enough to stand on the board.

Negative answers

My thoughts haven't really altered.

When the responses to the fifth question were examined, it became evident that the use of this strategy had had a favorable impact on the students' attitudes about math. Some students were heard saying things such, "I enjoyed the instruction, it was fun, and I liked mathematics anyhow." It was noted that the student who responded negatively also had unfavorable opinions on other courses.

DISCUSSION

The findings of the experimental group before and after testing differ significantly, according to the statistical analyses performed. Pre- and post-test outcomes in the control group differ, and when we compare them, we can see that the RME methodology is far more successful than the conventional approach. The efficiency of the RME-supported teaching approach in mathematics sessions was also evaluated by the researchers Ersoy (2013) and Bildircin (2012), who obtained results that demonstrated the usefulness of RME. These experimental work's results are somewhat linked to those of Ersoy (2013) and Bildircin (2012).

Fauzan (2002) in his research work made analyzes on the results of the experimental and control groups, and in order to find out the opinions of the students in the experiment, he made a survey for the students of the experimental group. His investigation demonstrated the efficacy of RME. Through observation and interviews with the experimental group, both groups also discovered that they appreciated the RME method and that the students found it helpful (Fauzan, 2002).

According to research works, there is a statistically significant difference between the academic achievement retention scores of the group that participated in activities created using Can's (2012) Realistic Mathematics Education approach and the group that participated in constructivist activities (Tunali, 2010). Similar to this, Ersoy (2013) concluded that the teaching approach supported by Realistic Mathematics Education improved student achievement and had a favorable impact on retention.

However, based on the case of this study being conducted in a girls' lyceum, there is a possibility that gender distribution may influence the results of the analysis. In the future, it can be thought that more research is needed in this direction in order to better understand whether this will affect the results.

CONCLUSION

The purpose of this study was to analyze the impact of teaching 7^{th} grade mathematics using the RME technique on students' success as well as to find out what the students thought about this method of instruction. The achievement pre-test results applied to the experiment group and control group were assessed at the beginning of the application, and it was evident that there was little difference between the two groups in terms of achievement scores, but fairly close. It can be proven that the experimental 7A and control 7B groups are comparable in this instance. The analyses revealed that there was a substantial difference between the experimental group's pre- and post-test scores. As a result, it can be said that the RME-based instruction was successful.

Do the students of control group's pre- and post-test achievement scores differ? The analyses performed to address the question show that there is a sizable difference. It is obvious that the average is greater, and the difference is more noticeable in the experimental group. In this instance, we may conclude that the RME's influence on the experimental group is greater than the effect of the approach used in the present program when applied to the control group. At the conclusion of instruction, both groups' success rates increased, but the experimental group's success rate increased more than the control group's, whose success rate increased as a result of the use of the teaching strategy recommended by the present curriculum.

The RME approach was generally well-liked by the students, they enjoyed it, it helped them overcome their anxieties about math, and they wanted to use it in the classroom, according to the results of the opinion form used with the experimental group. The facilitation of the students' learning process and an improvement in their collaboration have both been seen when lessons are taught in groups. Additionally, it was noted that some students, however marginally, had an unfavorable attitude of the RME approach. However, it might be stated that these issues have more to do with the application design than the RME's capabilities.

The students also noted that even when information is not repeated in class, students retain it, and this demonstrates the effectiveness of the RME method. Many students solve the worksheet questions quickly using proportion and mental calculations.

RECOMMENDATIONS

The research has shown that using the RME approach has a good impact on students' attitudes, achievements, and retention of the material they have learnt. The following suggestions can be made in light of these findings.

- A research may be done to find out how much RME knowledge new mathematics instructors have, and courses can be developed to give in-service training on the technique.
- Studies with undergraduate mathematics students or the material of a different course might be used to demonstrate this strategy.
- Lesson plans should be created in advance by teachers who plan to apply the RME approach in their classes. It requires a lot of time. The length of the lesson may be changed more readily with the preparations that need to be made. Additionally, rather of focusing on answering students' queries, teachers should take on the role of guides in the classroom and encourage students to work through problems on their own.
- If students are aware about RME prior to beginning the application, the instructional process will be more effective
- To gain the opinions of the students on how the subjects taught will help them in their everyday lives, appropriate discussion spaces can be built.
- Additionally, the RME technique may be applied with groups at various levels and in a variety of topic areas, allowing future study to evaluate how it affects students' academic progress in subjects other than algebra.

REFERENCES

Altun, M. (1989). Modern mathematics and the situation in our primary education. *Uludag University Journal of Education Faculties, 4*(1), 183-187.

Altun, M. (2002). *Primary education II: Teaching mathematics at secondary level (2nd Edition)*. Bursa: Alfa Publications.

Balci, A. (2018). *Research methods, techniques and principles in social sciences*. PEGEM.

Bildircin, V. (2012). *Effects of realistic mathematics education (RME) approach on teaching length, size and volume concepts among elementary education fifth grade students* [Master's thesis, Ahi Evran University].

Can, M. (2012). *The effect of realistic mathematics education approach on measurement in primary school 3rd grades on student achievement and permanence of learning* [Master's thesis, Abant Izzet Baysal University].

Cansiz, S. (2015). *The effect of realistic mathematics education approach on students' mathematics achievement and creative thinking skills* [Master's thesis, Ataturk University].

Crilly, T. (2013). *The big questions: Mathematics*. Quercus.

DiBattista, D., & Kurzawa, L. (2011). Examination of the quality of multiple-choice items on classroom tests. *Canadian Journal for the Scholarship of Teaching and Learning, 2*(2), 4. https://doi.org/10.5206/cjsotl-rcacea.2011.2.4

Ersoy, E. (2013). *The effect of realistic mathematics education supported teaching method on student achievement in teaching 7th grade probability and statistics achievements* [Master's thesis, Sakarya University].

Fauzan, A. (2002). *Applying realistic mathematics education (RME) in teaching geometry in Indonesian primary schools* [PhD thesis, University of Twente].

Frenkel, E. (2013). *Love and math: The heart of hidden reality*. Basic Books.

Freudenthal, H. (1991). *Revisiting mathematics education*. Kluwer Academic Publishers.

Gozkaya, S. (2015). *The effect of realistic mathematics education supported teaching method on student success and permanence of learning in teaching 7th grade ratio and proportion subjects* [Master's thesis, Erciyes University].

Hersh, R., & John-Steiner, V. (2010). *Loving and hating mathematics*. Princeton University Press. https://doi.org/10.1515/9781400836116

James, I., & Ioan, J. (2002). *Remarkable mathematicians: from Euler to von Neumann*. Cambridge University Press.

Kasymova, A. G., & Tashetov, M. M. (2017). *Methods of solving problems in percentages in school mathematics*.

Kaylak, S. (2014). *The effect of lesson activities based on realistic mathematics education on student achievement* [Doctoral dissertation, Necmettin Erbakan University].

Khurgin, I. I. (1974). *Did you say mathematics?* Mir.

King, J. P. (2006). *The art of mathematics*. Courier Corporation.

Kurt, E. S. (2015). *The effect of realistic mathematics education on achievement and retention in length measurement* [Master's thesis, Ondokuz Mayıs University].

Kwon, O. N. (2009). *Conceptualizing the realistic mathematics education approach in the teaching and learning of ordinary differential equations*. https://eric.ed.gov/?id=ED472048

Laurens, T., Batlolona, F. A., Batlolona, J. R., & Leasa, M. (2017). How does realistic mathematics education (RME) improve students' mathematics cognitive achievement? *EURASIA Journal of Mathematics, Science and Technology Education, 14*(2), 569-578. https://doi.org/10.12973/ejmste/76959

Letter. (2021). *On the peculiarities of the organization of the educational process in secondary schools of the Republic of Kazakhstan in the 2021-2022 academic year*. https://uba.edu.kz/storage/app/media/IMP/IMP_2021-2022_kaz.pdf

Livio, M. (2011). *Chúa trời có phải là nhà toán học?* [*Is God a mathematician?*]. https://www.nxbtre.com.vn/sach/khoa-hoc-kham-pha-chua-troi-co-phai-la-nha-toan-hoc-146702.html

Mailybaeva, G. S., Nurgaliyeva, S. A., Zhexembayeva, Z. R., Zholumbayeva, R. M., & Utegulov, D. E. (2018). The efficiency of the education system in Kazakhstan: Program for International Student Assessment (PISA). *Opción: Revista de Ciencias Humanas y Sociales* [*Option: Journal of Human and Social Sciences*], *85*, 600-626.

Memnun, D. S. (2011). *Investigation of the processes of primary school sixth grade students forming the concepts of coordinate system and line equation of analytical geometry* [Doctoral dissertation, Bursa Uludag University].

Parveva, T., Noorani, S., Ranguelov, S., Motiejunaite, A., & Kerpanova, V. (2011). *Mathematics education in Europe: Key challenges and national policies*. Publications Office of the EU.

Rényi, A. (2006). A Socratic dialogue on mathematics. In R. Hersh (Ed.), *18 unconventional essays on the nature of mathematics* (pp. 1-16). Springer. https://doi.org/10.1007/0-387-29831-2_1

Streefland, L. (1990). Realistic mathematics education (RME). What does it mean? In K. Gravemeijer, M. van den Heuvel-Panhuizen, & L. Streefland (Eds.), *Contexts free productions tests and geometry in realistic mathematics education*. OW & OC.

Torun, A. (2015). *The humor of mathematics* (1st ed.). Istanbul: 7 Color Printing.

Tunali, O. K. (2010). *Comparison of the concept of angle with realistic mathematics teaching and constructivist theory* [Doctoral dissertation, Bursa Uludag University].

Uygur, S. (2012). *The effect of realistic mathematics education on student achievement in teaching multiplication and division operations with fractions in 6th grade* [Master's thesis, Ataturk University].

van den Heuvel-Panhuizen, M. (1996). *Assessment and realistic mathematics education*. Technipress.

van den Heuvel-Panhuizen, M. (2003). The didactical use of models in realistic mathematics education: An example from a longitudinal trajectory on percentage. *Educational Studies in Mathematics, 54*(1), 9-35. https://doi.org/10.1023/B:EDUC.0000005212.03219.dc

Woodward, R. (2009). *The organisation for economic co-operation and development (OECD)*. Routledge. https://doi.org/10.4324/9780203875773

Zulkardi, Z. (2000). *Realistic mathematics education theory meets web technology*. https://www.semanticscholar.org/paper/Realistic-Mathematics-Education-Theory-Meets-Web-Zulkardi/924a3867717c12bb590eb2f1ec6d225d7aef5036

Zulkardi, Z. (2002). *Developing a learning environment on realistic mathematics education for Indonesian student teachers* [Doctoral dissertation, University of Twente].

Zulkardi, Z., Nieveen, N., van den Akker, J., & de Lange, J. (2002). *Implementing a 'European' approach to mathematics education in Indonesia trough teacher education*. http://users.math.uoc.gr/~ictm2/Proceedings/pap81.pdf

Please cite: Patullayeva, K. N. (2022). Effects of Realistic Mathematics Education on Students' Academic Performance. *Journal of Research in Didactical Sciences, 1*(1), 12515. https://doi.org/10.51853/jorids/12515

Received: 26 June 2022 ● Accepted: 28 August 2022

Journal of Research in Didactical Sciences
ISSN: 2997-5905 (Online)
VOL. 1, ISSUE 1, 2022
Article No: 12701

RESEARCH ARTICLE

OPEN ACCESS

Supporting Construction Technology Students' Outside-of-Classroom Teaching and Learning Physics at One Rwanda Polytechnic College Using a Screencast Application

Jean Claude Uwayezu [1*], Tharcisse Renzahoduke [1]

[1] Rwanda Polytechnic, Rwanda
* Corresponding author: basanande2014@gmail.com

Abstract: The use of information and communication technology in teaching and learning science is appreciated to enhance students' learning process by allowing teachers to create virtual environments and this has been among sustainable solutions since the outbreak of the COVID-19 pandemic. This study aimed to assess the extent to which screencast application's learning materials support construction technology students' outside-of-classroom learning in physics at one Rwanda Polytechnic College. It was a quantitative case study conducted on 128 students who were undertaking the course of physics fundamentals. Screencast application's learning materials about the topic of thermodynamics were provided during a period of five weeks in parallel with usual teaching and learning and students used them for outside-of-classroom learning. At the end of this intervention, a Likert scale questionnaire was administered to participating students to assess their satisfaction on the support they have received. Only 80 students successively responded to all the questionnaire items and their responses were analysed using percentage frequencies and arithmetic means of Likert scale point scores. The results indicated that students' satisfaction on the received support was relatively good for collaborative learning (M=4.02, SD=0.04), motivation to learn physics (M=4.14, SD=0.07), independent learning in physics (M=4.13, SD=0.07) and understanding of the topic of thermodynamics (M=4.04, SD=0.08). At the studied college, it was concluded that screencast application's learning materials support first-year construction technology students' in their outside-of-classroom learning in physics in good help and good gain category. Scientific studies on the effect of screencast applications on students' performance in physics are also recommended for large samples in Rwanda Polytechnic College.

Keywords: outside-of-classroom learning, screencast application, VSDC screen recorder

INTRODUCTION

Background of the Study

Physics subject is very essential in the engineering and technology education. Engineering students need to use different physics laws and principles in problem solving while developing new systems for real-life applications (Jalil et al., 2020). In this regard, physics is considered as a universal language in the engineering community (Denisova, 2020). Due to this importance, physics subject has been included in almost all engineering and technology curricula, across the world, as a fundamental science subject. However, in some contexts, engineering students do not confidently connect what they learn in physics to the applications in engineering and this can lead to less students' focus on learning physics (Gouripeddi et al., 2018). In a study conducted in a Chilean university, engineering students showed less appreciation on the importance of physics and mathematics in their courses and their professional career (Zavala & Dominguez, 2016). Particularly in structural engineering, in another study, Peñaranda et al. (2020) have related this lack of connection to inadequate teaching strategies and propose the teaching of physics that connect students' common sense and the required expert knowledge in structural engineering. They suggest the use of visual, auditory and tactile resources in teaching physics.

Thermodynamics is one of the difficult physics topics for engineering students. Due to the abstract nature of the concepts of heat and temperature involved in this topic, some students develop misconceptions about it (Ahmad & Salleh, 2021). Particularly, civil engineering students are among students who showed misconceptions on concepts of heat transfer and thermodynamics and this has been linked to poor teaching strategies used by some instructors (Yang et al., 2020). The inadequate teaching may discourage students in learning this topic and their failure may lead to their less interest in learning thermodynamics. In the survey conducted at different universities in seven (7) countries, it was found that the majority of engineering students find thermodynamics not-so-interesting or boring (Ugursal & Cruickshank, 2015). However, in the same study, it was highlighted that the reality is that this topic is very interesting for those who understand it. Thus, authors advise teachers to use strategies which will make thermodynamics interesting and exciting.

At Integrated Polytechnic Regional Colleges (IPRCs) in Rwanda Polytechnic (RP), thermodynamics is one of the topics in physics fundamentals taught in most of engineering options. Particularly, construction technology students do not have other related modules to deepen this topic. With the usual teaching learning, the time allocated for classroom meetings cannot suffice each individual student in terms of practical exercises and problem-solving activities. In fact, the need for outside-of-classroom learning is important for both independent and collaborative learning. However, the use of virtual reality technologies in IPRCs, for classroom practices, is still with less focus (JICA, 2021). Usually, students use handouts, library textbooks learning videos and written homeworks for learning off-campus. This is in contrast with the great demand of blended learning model during and after the COVID-19 era.

Objective of the Study

This study aimed to assess the extent to which screencast application's learning materials support first year construction technology students' outside-of-classroom teaching and learning in physics at one IPRC. This study is the benchmark for distance education for science subjects in RP.

Review of the Literature

Instructional scaffolding in physics teaching and learning: Efficient pedagogies are hoped to tackle the problem of learning difficulties in physics, shifting from traditional and inefficient ones, as reported in many studies seeking to improve teaching and learning physics. One of the promising strategies, as investigated in many studies about teaching and learning physics, is the instructional scaffolding. Instructional scaffolding is the instructional strategy in which students are supported to learn and complete different learning tasks beyond the knowledge and skills acquired previously (Bileya & Comfort, 2021). Saputri and Wilujeng (2017) argue that the efficient physics learning occurs when students are supported to complete different tasks that they have never learned before. This strategy has provided students with opportunities to construct knowledge and skills in physics through independent and collaborative learning. In the study conducted to evaluate the support of scaffolds to the development of scientific skills in physics during scientific inquiry, it was observed that students in the experimental group were well helped by the designed scaffolds compared to the control group (Ferreira-Bautista & Pifarré, 2019).

Different models of scaffolding have been used in physics teaching and learning. One scaffolding modality that supports the information and communication technology (ICT) integration in physics teaching and learning is the computer-based scaffolding for which the supports to students are given in the form of computer-stored materials (Ferreira-Bautista & Pifarré, 2019). Interestingly, these computer-prepared materials provide support to the interaction that can even occur outside the classroom. This form of scaffolding has been used in physics education and has positively impacted students' physics learning (Kim et al., 2018; Saputri, 2021; Sobirin et al., 2018).

Screen capture technologies in physics teaching and learning: Different screen capture applications are appreciated to support students' learning mostly in the flipped classroom settings. In the study conducted to explore the flipping science classroom and examine its merits, issues and pedagogy, it is argued that the use of computer screen recordings can help physics teachers to prepare learning materials like derivation of formulas and explaining phenomena through simulations (Wan, 2014). In this study, it is also revealed that there are different free screen recording applications that can be used in teaching and learning physics. Screen captures can also be used during the power point presentation explaining important concepts (Bell et al., 2020).

On the other hand, a study was conducted to compare students' conceptual learning about gas properties when interacting with simulations and when observing screencasts (Martinez et al., 2021). This study was conducted in the Midwest Region of the USA, and it showed significant learning gains for both modes of learning. However, it was revealed that it could be better if the use of screencasts precedes the use of simulation to improve learning.

Recently, after the COVID-19 pandemic outbreak and the closure of schools and colleges across the world, the use of screencasts has been another option to prepare and deliver teaching online. For example, in the study conducted to assess the usability of screencast in the first basic physics lectures during the COVID-19 pandemic, the analysis of students' perceptions were all in high category and this ICT tool is seen to be effective in improving students' knowledge and skills (Susanti et al., 2021). However, this study did not investigate its pedagogical implications in special learning settings including scaffolding and flipped classrooms.

Factors affecting students' outside-of-classroom learning in physics: The outside-of-classroom learning in physics has received a notable attention especially in the form of flipped classroom and scaffolding strategies. The revision of this practice in order to establish meaningful learning is always important for physics instructors and this is pertained to their planning, implementation and evaluation of learning. In this line, different studies have elaborated a number of factors that can influence the outside-of-classroom learning in different settings. The course design and educator's role are two considerable factors that influence the outside-of-classroom learning. The course design affects students' satisfaction (Anne-Mannette, 2018). In physics teaching and learning students' satisfaction brings motivation and positive attitudes towards learning the subject. On the other hand, it is also claimed that course design affects students' perception (Anne-Mannette, 2018). This is an important dimension in modeling the meaningful learning in physics because positive perceptions lead to good students' decisions that they take for their own learning. The influence of the educator is due to the fact that the efficient teaching is when the educator facilitates learners through regular communication with students, providing consistent feedback to different students' queries and monitoring the learning process for the sake of guidance. Environment and peers are also recognized to have an influence on the students' outside-of-classroom learning in physics. In the study aimed to expand physics learning beyond the classroom boundaries using WhatsApp for secondary physics teaching and learning, it was found that the supporting atmosphere and learning community created by the teacher have improved the learning progress (Klieger & Goldsmith, 2020). Spaces and learning community have also been identified to be factors affecting the online learning in the form of blended learning (Anne-Mannette, 2018). However, in this study it is argued that the absence of face-to-face environment in asynchronous online teaching may reduce the in-person interaction between students and the instructor. This is not a problem in the current study employing the instructional scaffolding because both face-to-face and continuous support have been provided. The WhatsApp group was used for communicating ideas while students can also meet physically to discuss different issues in the course. Students groups are considered as peers and this promotes collaborative learning.

Student identity is a crucial factor which affects many aspects of student learning in physics for both inside-of-classroom and outside-of-classroom. For example, self-regulation of learning is seen as a required competency for students to model their independent learning (Rohini et al., 2016). Physics learning requires a student self-efficacy, setting individual learning goals and always makes reflections on the learned materials. Self-regulated students are able to control their learning progress and pace. The outside of classroom is reach of many distractors which may attract students and they can lose concentration on learning. However, self-regulated students are able to control their surroundings and stay in the right track.

Theoretical Framework

The current study was guided by the Vygotsky's scaffolding theory. According to this theory, the learning support received by a learner from the tutor or peer, is temporary and dynamic following the Zone of Proximal Development (ZPD) of the learner (Gonulal & Loewen, 2018). There must be the consideration of actual student's performance and his/her potential level in acquiring knowledge (Malik, 2017). In the current study, the screencast application's learning materials were prepared basing on the current students' knowledge and the prescribed performance criteria in the topic of thermodynamics. This practice is in accordance with the competence-based training (CBT) and competence-based assessment (CBA) facilitation implemented in RP, where teachers are requested to monitor and evaluate the learning progress of each individual learner and provide necessary support until the learner fulfils the performance standards. Physics teachers consistently assessed the students' performance on different learning outcomes during the learning process in thermodynamics and prepared the supports accordingly.

METHODS

Research Design

This research was a quantitative case study conducted at IPRC Gishari which was selected purposively As it was highlighted in the survey on technical and vocational education and training (TVET) in Rwanda, in 2021, IPRC Gishari came among four of eight RP Colleges in which the use of virtual reality (VR) in teaching and learning was not practiced (JICA, 2021). Considering the location and the presence of the option of construction technology, IPRC Gishari was a relevant choice for the current study.

Together with the usual teaching methods of CBT and CBA, adopted in RP, the integration of screencast application in the teaching and learning physics was done by physics teachers at the College, in the option of construction technology for five weeks. During this period, between May and June, the following topics were covered with the use of Video Software Development Company (VSDC) screencast application:

1. Temperature measurement on a body
2. Heat measurement, transfer and effect on a body
3. Ideal gas laws
4. Application of laws of thermodynamics.

Participants

This study was targeting first-year construction technology students at one IPRC who were enrolled in the academic year of 2021/2022, totalling to 128 students and undertaking the course of physics fundamentals in the first semester, 2022. The studied students' group was abundantly composed of boys (89%) and very few girls (11%). Most students were in the age range between 20 and 25 years old (79%). According to Hashim (2018), most of the participants were born between 1995 and 2010 and thus belongs to the Generation Z. Learners in this generation are friendly in using social media in communication and prefer flexible learning environments to avoid being bored.

Data Collection and Analysis Techniques

In each week, apart from traditional classroom sessions, students received additional learning materials in the form of screencast on different learning outcomes about thermodynamics, in line with the competences prescribed in the curriculum of construction technology option. These materials were prepared according to different students' queries and results of formative assessments about the topic. The VSDC Free Screen Recorder, version 1.3, was used for producing the recordings in moving picture expert group, layer 4 (MP4) format. The materials were focusing on the conceptual understanding and problem solving in thermodynamics for its application in engineering. The learning materials were shared using the usual WhatsApp group in collaboration with class representatives for each of three parallel classes.

A structured questionnaire with twenty (20) items in the form of Likert scale, was administered to the students at the end of the course. The questionnaire items intended to assess the learning support gained by students through the screencast application's learning materials. The support was reflected in four dimensions. These dimensions include learning physics outside of the classroom in terms of students' collaborative learning, students' motivation to learn, students' independent learning and students' confidence of mastering the topic. For example, in collaborative learning, students were asked how the screencast application has helped them to participate in group works for assigned home activities. For motivation to learn physics outside the classroom, one item was asking students about the support of the screencast application for their interests to plan for additional reading to satisfy

Table 1. Scoring range of Likert scale of survey (Sözen & Güven, 2019)

Statement	Value	Range
No help / gain	1	1.00-1.80
Little help / gain	2	1.81-2.60
Medium help / gain	3	2.61-3.40
Good help / gain	4	3.41-4.20
Very good (great) help / gain	5	4.21-5.00

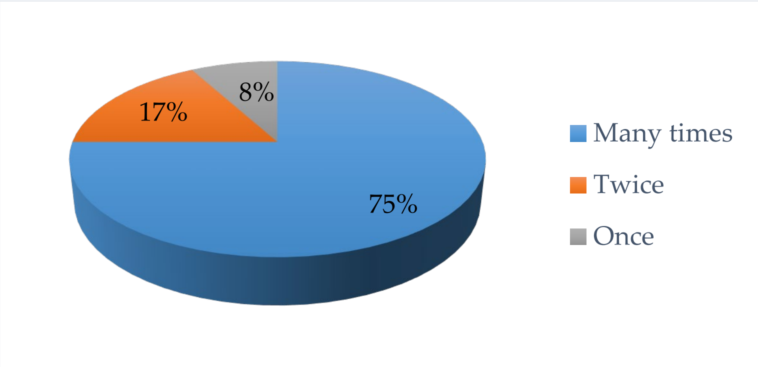

Figure 1. Frequency of students' use of screencast application learning materials

their curiosities. The participants were also asked about the support of the screencast application in evaluating their weaknesses and strengths in learning physics, for independent learning. Finally, for student's confidence, one item was asking about the support of the screencast application to improve the ability to use appropriate formulas in solving problems in physics, especially in the topic of thermodynamics.

The questionnaire items have been adopted from two standard instruments, namely the "Student Assessment of Learning Gains (SALG)" and "Motivation Scale towards Physics Learning (MSPL)" which are found on the American physics education research assessments website: https://www.physport.org/assessments/. The questionnaire was administered in the online format using the Kobo toolbox server.

The questionnaire items were of two categories including items regarding the students' learning gain from the provided support and items regarding the help to the students' learning process from the provided support. In the former, for each question aspect, the student was asked to show the level of his/her learning gain with points 1=no gain (NG), 2=little gain (LG), 3= moderate gain (MG), 4= good gain (GG) and 5= great gain (GrG). In the latter, for each question aspect, the student was asked to show the level of help received with points 1=no help (NH), 2=little help (LH), 3= moderate help (MH), 4= good help (GH) and 5= great help (GrH). Only 80 respondents have returned the questionnaires and their responses were used in data analysis. Percentage frequencies and the arithmetic means on the Likert-type questionnaire responses were used to analyze the data in this study.

RESULTS

The aim of this study was to assess the extent to which screencast application's learning materials support construction technology students' outside-of-classroom learning physics in Rwanda Polytechnic Colleges. To achieve this, the study intended to answer to the research question: to what extent do screencast application's learning materials support construction technology students' outside-of-classroom learning physics in Rwanda Polytechnic Colleges? First of all, it was needed to know how many times used the provided screencast application's learning materials in their outside of-classroom learning physics. The results are summarized in the pie chart presented in **Figure 1**.

Figure 1 shows that a big number of students (75%) used the provided screencast application's learning materials more than twice during their outside of classroom learning in physics. However, there are some few students who used the learning materials only twice (17%) and very few used it only once (8%). On the other hand,

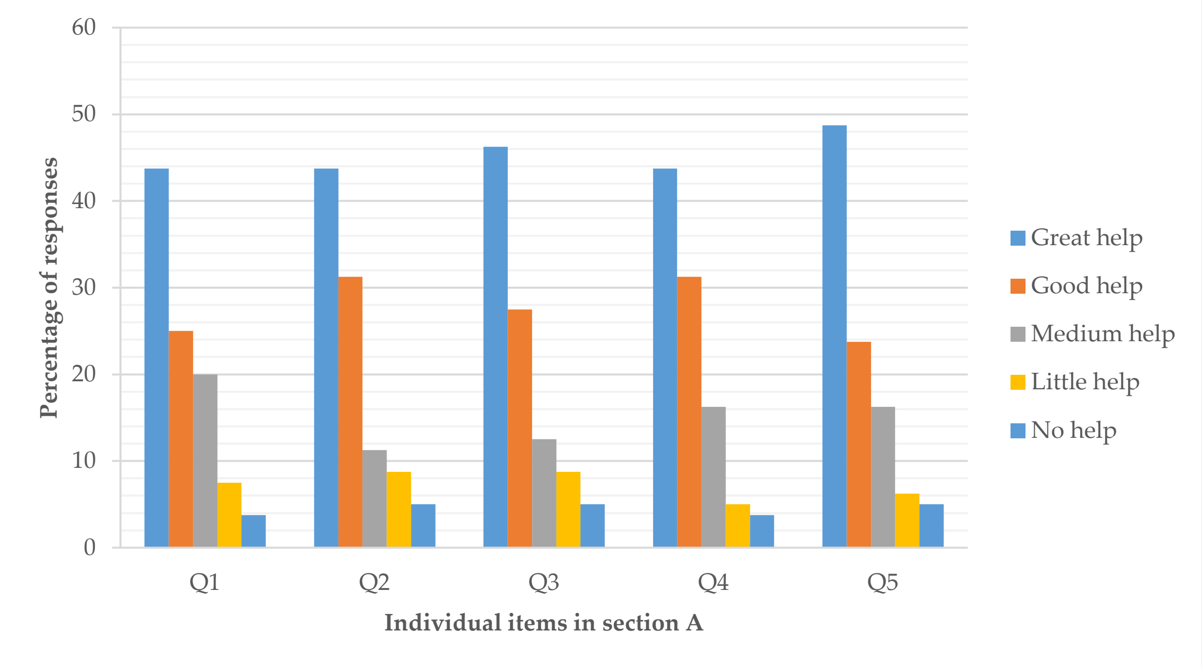

Figure 2. Students' ranking on screencast application support to their collaborative learning

researchers wanted to account for the extent to which the screencast application's learning materials supported construction technology students in collaborative learning in physics, outside of the classroom.

Due to this, the first five (5) questionnaire items, grouped in section A, were prepared to allow respondents give their satisfactions on the support they have received from the materials in collaborative learning. As it is for other sections, here the ranking was classified in five (5) levels, from the least to the best: no help, little help, moderate help, good help and great help. The corresponding results are presented in the **Figure 2**.

Figure 2 indicates that many students ranked the support about collaborative learning in physics in the "great help" category in all five. The highest percentage, 48.75%, is observed on the fifth item. This item intended to see the students' satisfaction on the help received from the screencast application's learning materials to help their classmates and engage them in the learning of physics outside the classroom. The lowest percentage (44%) is observed on three items including item 1, item 2 and item 4. These items were on the students' ranking the help they received about their participation in group discussions, group work activities and hands-on activities for the success of the whole group respectively. Another information that can be read from **Figure 2** is that the second highly ranked support is "good help" category which is in the range between 23.75% and 31.25%. Moreover, the category of "no help" has seen the least rank. The students' ranking for this category ranges from 3.75% to 5%. The average score point on students' perception was in the good help range (M=4.02, SD=0.04).

Another group of five (5) items was formed in section B. These items intended to figure out the extent to which the screencast application's learning materials improved students' motivation to learn physics outside the classroom. Students were asked to rank from no gain to great gain about their feeling on the received support. The results are presented in **Figure 3**.

Figure 3 shows that many students ranked the received support from the screencast application's learning materials to their motivation to learn physics in the "great gain" category whose percentages range between 48.75% and 52.5% for all five (5) items. Particularly, item 6 which was asking students to rank the support received on doing their own reading or studying before coming to usual classroom, has received the highest ranking (52.5%). Similarly to the section A, the second highly ranked category in section B is "good gain" category whose percentages range from 20% to 31.25%. On the other hand, the categories of "no gain" and "little gain" have received lower ranking which ranges from 1.25% to 3.75% and from 3.75% to 10% respectively whereas the category of "medium gain" was ranked from 13.75% to 20%. In this category, the average score point was (M=4.14, SD=0.07), which is in the good gain range.

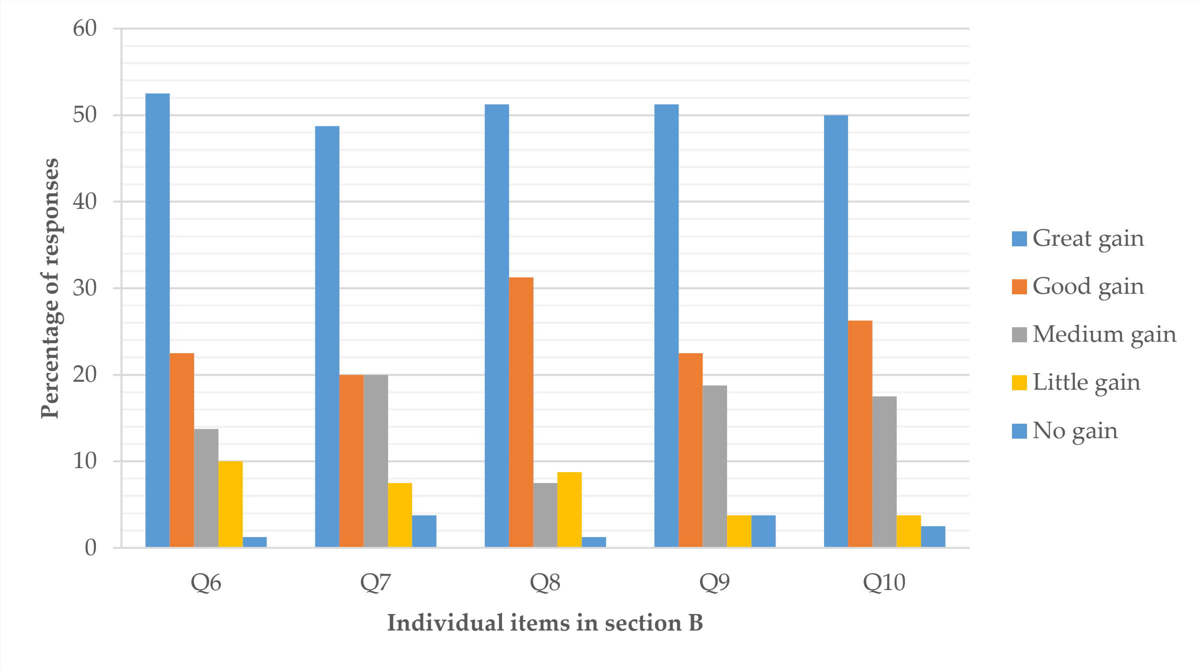

Figure 3. Students' ranking on screencast application support to their motivation to learn physics

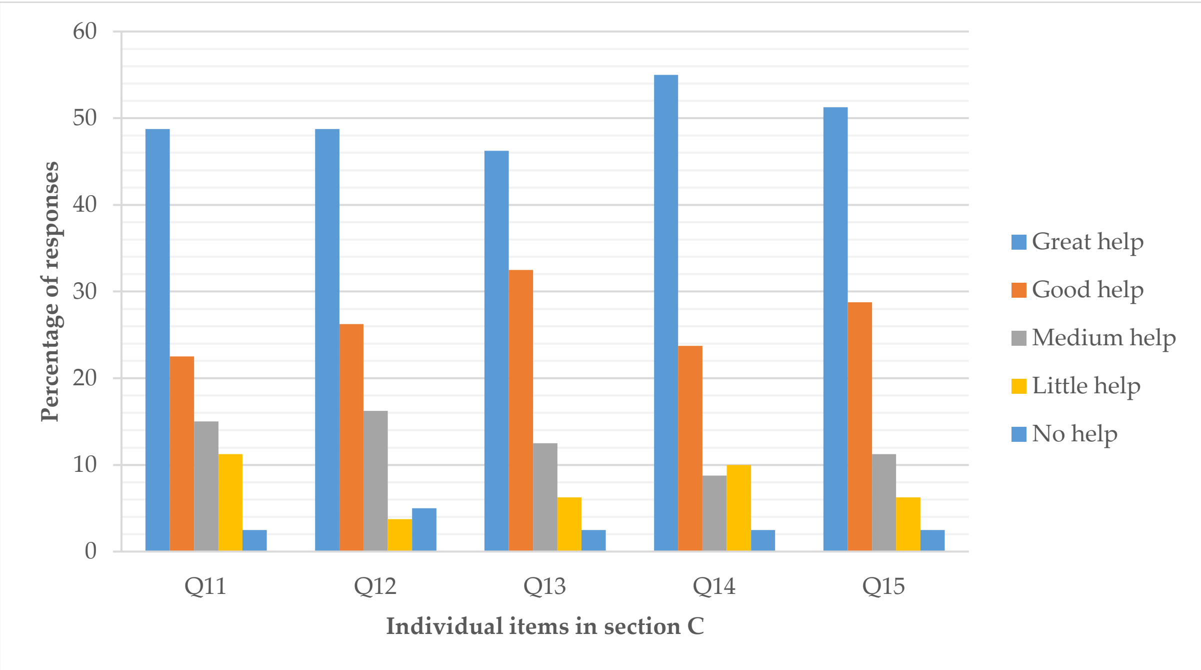

Figure 4. Students' ranking on screencast application support to their independent learning

In section C, five (5) questionnaire items intended to measure the extent to which students feel to have been helped by the screencast application's learning materials during their independent learning in physics outside the classroom. The corresponding results for this section are summarized in **Figure 4**.

As it is revealed in **Figure 4**, the highest percentage of students ranked the received support in the "great help" category with the range being from 46.25% to 55%. Particularly on items 14 and 15 more than half of students (55% and 51.25%) felt that the screencast application's learning materials supported them in making their summary and know where they are weak and strong in physics learning respectively. In this section, the category of "good help" is positioned on the second place of ranking, ranging from 22.5% to 32.5% of respondents. The third place is

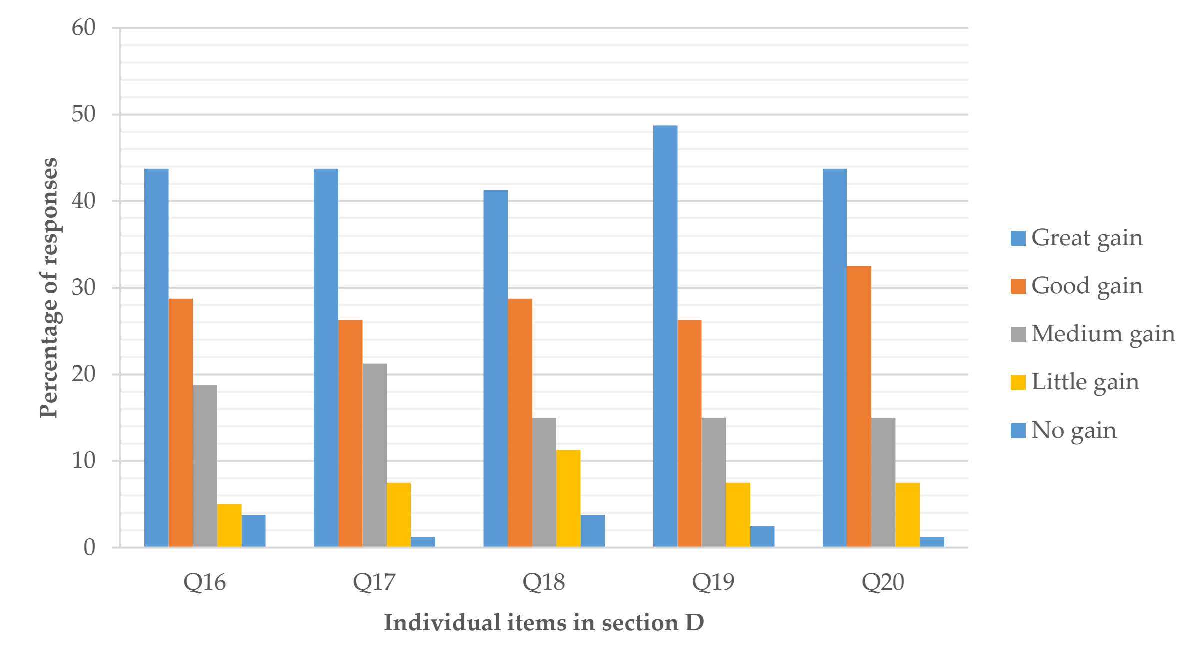

Figure 5. Students' ranking on screencast application's support to their active mastery of thermodynamics

occupied by the category of "medium help" with the percentage of respondents ranging from 8.75% to 16.25%. The two other categories, "little help" and "no help", occupy the fourth and the last place respectively. The former has the respondent percentage within the range from 3.75% to 11.25% whereas that for the latter is 2.55%. The average score point was (M=4.13, SD=0.07), classified in the good help range.

Lastly, another group of five (5) items was grouped in the last section, named D. These questions had the objective of probing students' level of satisfaction on how they think they have actively mastered the topic of apply thermodynamics with the support from the screencast application's learning materials. The questionnaire items in section D were targeting students' ranking on the support received to their understanding of thermodynamics, their awareness on application of thermodynamics in engineering, how they use formulas, how they use diagrams and appropriate laws in problem solving in thermodynamics. The results in this part are summarized in **Figure 5**.

Figure 5 reveals that the highest percentage of students is for the category of "great gain" in all five items. It ranges from 41.25% to 48.75%. The category of "good gain" is the second highly scored by students with the respondents' percentage ranging from 26.25% to 32.5%. The third place is taken by the category of "medium gain" in the percentage range of 15%-21.25%. On the other hand, the fourth and last places are occupied by the categories of "little gain" and "no gain" whose students' percentage ranking them is in the range of 5%-11.25% and 1.25%-3.75% respectively. Finally, the average score point for questions related to understanding of physics was (M=4.04, SD=0.08), in the good gain range.

DISCUSSION

The aim of this study was to assess the extent to which the screencast application' learning materials support first-year construction technology students' outside-of-classroom learning in physics at one IPRC. After a five-week of teaching the topic of thermodynamics, a questionnaire was administered to the research participants. It was grouped in four dimensions: support regarding collaborative learning, independent learning, motivation to learn physics and understanding of physics. The results have been summarized in the findings section. Although the current study involved a higher percentage of males than females, findings are discussed irrespective of gender as some previous studies have shown no significant difference in students' performance between genders in the blended learning environments (Gambari et al., 2017; Keržič et al., 2019; Zhang et al., 2022). However, the dominant participants' age group has been considered in the discussion.

Support of Screencast Application' Learning Materials to Students' Collaborative Learning in Physics

Results about the support of screencast application's learning materials to students' collaborative learning in physics outside of the classroom showed that a high percentage of students classified the support in first three categories: great help, good help and medium help. In total, this group has got the minimum of 78.75% of students' choice on the support on collaborative learning and it shows that on five questionnaire items, a maximum of 21.25% of students perceived that the support was not appropriate in their learning. In general, the average score point in this category, which is (M=4.02, SD=0.04), indicated that students had good satisfaction on the support of screencast application' learning materials to their collaborative learning in physics outside the classroom. These findings can be associated with the characteristics of the participants. Hashim (2018) describes the Gen-Z as learners who like to learn by collaborating through small teams or groups. On the other hand, the use of recorded videos has been seen to be essential in creating collaborative learning environments (Murillo-Zamorano et al., 2019), which is reflecting the results in the current study. Collaborative learning in physics outside the classroom, as captured in this study, considers group discussions, active participation in group works, supporting and engaging classmates in learning physics as well as doing hands-on activities in order to find solutions to group work problems for the success of the whole group. In fact, through the use of screencast application's learning materials in the outside of classroom learning physics, many students have overcome different learning difficulties and became active learners in their groups. The findings about collaborative learning in this study are in agreement with some similar studies. Andersen and Korpås (2022) argue that students engage themselves to work together when they pay attention to the learning materials played on the screen of a computer.

Support of Screencast Application's Learning Materials to Students' Motivation to Learn Physics

The second section of the questionnaire comprised five (5) items asking students to rank the support received in terms of the gain in motivation to learn physics. The high students' percentage (minimum of 82.5% on all five items), have positively admitted the support of screencast application's learning materials to their motivation to learn physics. The average score point, (M=4.14, SD=0.07), has also confirmed it. On the other hand, a maximum of 17.5% have not positively admitted the support. In this section, it is clear that students were well motivated to learn physics through the use of this ICT tool. These findings reflect the IPRC Kigali students' perception on the importance of using ICT in their learning process as reported in the study conducted by Rwamasirabo (2019). This study has shown that 83.33% of 18 participating students perceived that ICT use could increase their interest in courses. Moreover, given that the current study involved students' use of smartphones to access and share the learning materials, the findings are in accordance with the conclusions in the investigation about the use of smartphones by TVET students in South Africa (Shava et al., 2016). In this investigation, it is highlighted that smartphones are considered as supporting tools in cultivating desire to learn. Similarly, the study conducted by Eveline et al. (2019) on scaffolding approaches assisted by PhET simulations found that the use of computer simulations with scaffolding affects positively students' interest in learning. As it is described, the students' motivation increases and they become active learners.

Support of Screencast Application's Learning Materials to Students' Independent Learning in Physics

Results in section C about students' ranking on the support of screencast application's learning materials to their independent learning in physics outside the classroom indicated that more than 77.5% participating students classified the support in the first three categories described as positive support. This is again confirmed by the average score point of (M=4.13, SD=0.07) in the good help category. This shows that students believed that they were well supported to learn physics independently outside the classroom. The findings in this section are in agreement with other recent studies across the world and in the region. For example, Oktavianti et al. (2018) found that the e-scaffolding supports students' independent and collaborative learning in blended physics learning. In another study about problem-centred STEM education, Kim et al. (2020) similarly found that computer-based scaffolding affects positively the students' individual learning in problem solving. Moreover, the scaffolding strategy used with PhET simulations in physics teaching has been recorded a meaningful improvement on Indonesian high school students' learning independence (Eveline et al., 2019).

Support of Screencast Application's Learning Materials to Students' Understanding of Physics

The last section of the questionnaire was targeting students' confidence on their understanding of physics, especially on the topic of thermodynamics. Students were asked to rank their level of gain in understanding this topic for different aspects covered in five (5) questions. The results in this category showed that a high percentage of students ranked the support of screencast application's learning materials in the first three categories as it was in the previous sections. In the first three categories, considered in this study as positive support, we found 82.5% of students whereas 17.5% classified the support in the negative category of little gain and no gain. The average score point in this section, (M=4.04, SD=0.08), has also indicated that participating students have ranked the support to the understanding of thermodynamics in the category of good gain. As the ranking of students indicates, there are opportunities to consider with the support of screencast application's learning materials in comparison with other studies. In physics teaching and learning, the use of ICT in scaffolding develops more scientific skills in students as found in in the study by Ferreira-Bautista and Pifarré (2019). Further, the e-scaffolding in physics teaching provides students with opportunities to improve their ability in problem solving (Saputri & Wilujeng, 2017). Moreover, using web-based e-scaffolding, Sarah et al. (2022) found that e-scaffolding improve students' learning outcomes and understanding in physics due to attractive learning materials and learning experience faced. These findings are closely in line with students' level of confidence as they have ranked their understanding of physics through the screencast application's learning materials' support. The questions in this category reflected on students' understanding of physics concepts, use of diagrams, equations and graphs in problem solving in the topic of thermodynamics.

CONCLUSION

The aim of this study was to assess the extent to which the screencast application's learning materials support construction technology students' outside-of-classroom learning in physics. The study involved first-year construction technology students at one IPRC. On the five point Likert scale questionnaire, results of this study indicated that in all four dimensions students were positively satisfied with the support provided by the teacher through screencast application's learning materials. In all four cases, a high percentage of students was at least above 77.5%, in the first three levels: great help or great gain, good help or good gain and medium help or medium gain. Moreover, the average point scores on the Likert scale in all four learning dimensions showed that students had positive ranking on the received support, in the range of good help or good gain.

Recommendations

The sampled students were only first-year construction technology at one IPRC. This has limited researchers to generalize the findings to the whole Rwanda Polytechnic students' community. Moreover, the study had only considered students' satisfaction on a questionnaire and no other aspects of measurement in the learning process. Thus, researchers recommend future studies to consider large samples including all students who study physics or other science subjects in Rwanda Polytechnic. Studies which can also assess the effect of screencast application's learning materials on student performance in physics are encouraged in order to use these applications in daily teaching and learning physics and science subjects at Rwanda Polytechnic. Future studies also are recommended to create an online system where the screencast application's learning materials can store and students can download them any time on different occasions.

The Limitation of the Study

The current study encountered some limitations including the handling of student-teacher interaction with more than 100 students who were included in the study. It was challenging to give feedback to every participant in a convenient time and this could have affected the learning process. Moreover, sharing the learning materials with WhatsApp was seen to be not as sustainable as it could be. Sometimes, students had the problems with their smart phones and they could lose the materials. This has hindered the efficiency of teaching and learning.

REFERENCES

Ahmad, S. R., & Salleh, S. (2021). Effects of conceptual change-based teaching on the understanding of heat and temperature concepts among technical and vocational education and training (TVET) students with different demographic background. *International Journal of Academic Research in Business and Social Sciences, 11*(3), 59-75. https://doi.org/10.6007/IJARBSS/v11-i3/8918

Andersen, T. H., & Korpås, G. S. (2022). A qualitative study on how to scaffold for collaborative learning in an innovative learning area, a student perspective. *Uniped*, *45*(2), 142-152. https://doi.org/10.18261/uniped.45.2.6

Bell, M., Shumway, S., & Wright, G. (2020). An investigation of the impact of a flipped classroom instructional approach on high school students' content knowledge and attitude towards the learning environment. *Advances in Social Sciences Research Journal*, *7*(5), 338-349. https://doi.org/10.14738/assrj.75.8259

Bileya, S. G., & Comfort, B. T. (2021). Effect of instructional scaffolding on physics students' achievement in secondary schools in Taraba State, Nigeria. *International Journal of Advanced Academic Research*, *7*(9), 14-22.

Denisova, O. A. (2020). Motivation of technical university students to study physics and methods of teaching it in the context of a pandemic. *Journal of Physics: Conference Series*, *1691*, 012025. https://doi.org/10.1088/1742-6596/1691/1/012025

Eveline, E., Jumadi, Wilujeng, I., & Kuswanto, H. (2019). The effect of scaffolding approach assisted by PhET simulation on students' conceptual understanding and students' learning independence in physics. *Journal of Physics: Conference Series*, *1233*, 012036. https://doi.org/10.1088/1742-6596/1233/1/012036

Ferreira-Bautista, J., & Pifarré, M. (2019). Scaffolds to support the development of scientific skills in physics. *Journal of Physics: Conference Series*, *1287*, 012030. https://doi.org/10.1088/1742-6596/1287/1/012030

Gambari, A. I., Shittu, A. T., Ogunlade, O. O., & Osunlade, O. R. (2017). Effectiveness of blended learning and e-learning modes of instruction on the performance of undergraduates in Kwara State, Nigeria. *Malaysian Online Journal of Educational Sciences*, *5*(1).

Gonulal, T., & Loewen, S. (2018). Scaffolding technique. In J. I. Liontas, M. DelliCarpini, & C. Coombe (Eds.), *The TESOL encyclopedia of English language teaching* (pp. 1-5). John Wiley & Sons, Inc. https://doi.org/10.1002/9781118784235.eelt0180

Gouripeddi, S. P., Kannan, V., & Mahadasu, V. (2018). Tutorials in engineering physics using cooperative learning: A reflective introspection. In *Proceedings of the 2018 IEEE 18th International Conference on Advanced Learning Technologies* (pp. 268-269). IEEE. https://doi.org/10.1109/ICALT.2018.00129

Hashim, H. (2018). Application of technology in the digital era education. *International Journal of Research in Counselling and Education*, *1*(2), 1. https://doi.org/10.24036/002za0002

Jalil, J. M. N., Alvarez, E. R., Garcia, I. R. K., & Almaguer, S. P. (2020). Work in progress: Design and construction of physics laboratory equipment and an authentic evaluation system as a pedagogical tool in the integral training of engineering students. In *Proceedings of the IEEE Global Engineering Education Conference* (pp. 1471-1477). https://doi.org/10.1109/EDUCON45650.2020.9125294

JICA. (2021). Data collection survey on technical and vocational education and training in the Republic of Rwanda. *Japan International Cooperation Agency*. https://openjicareport.jica.go.jp/pdf/12357299.pdf

Keržič, D., Tomaževič, N., Aristovnik, A., & Umek, L. (2019). Exploring critical factors of the perceived usefulness of blended learning for higher education students. *PLoS ONE, 14*(11), e0223767. https://doi.org/10.1371/journal.pone.0223767

Kim, N. J., Belland, B. R., & Walker, A. E. (2018). Effectiveness of computer-based scaffolding in the context of problem-based learning for STEM education: Bayesian meta-analysis. *Educational Psychology Review*, *30*(2), 397-429. https://doi.org/10.1007/s10648-017-9419-1

Kim, N. J., Belland, B. R., Lefler, M., Andreasen, L., Walker, A., & Axelrod, D. (2020). Computer-based scaffolding targeting individual versus groups in problem-centered instruction for STEM education: Meta-analysis. *Educational Psychology Review, 32*(2), 415-461. https://doi.org/10.1007/s10648-019-09502-3

Malik, S. A. (2017). Revisiting and re-representing scaffolding: The two gradient model. *Cogent Education, 4*(1), 1331533. https://doi.org/10.1080/2331186X.2017.1331533

Martinez, B. L., Sweeder, R. D., VandenPlas, J. R., & Herrington, D. G. (2021). Improving conceptual understanding of gas behavior through the use of screencasts and simulations. *International Journal of STEM Education, 8*, 5. https://doi.org/10.1186/s40594-020-00261-0

Murillo-Zamorano, L. R., Sánchez, J. Á. L., & Godoy-Caballero, A. L. (2019). How the flipped classroom affects knowledge, skills, and engagement in higher education: Effects on students' satisfaction. *Computers & Education, 141*, 103608. https://doi.org/10.1016/j.compedu.2019.103608

Oktavianti, E., Handayanto, S. K., Wartono, W., & Saniso, E. (2018). Students' scientific explanation in blended physics learning with e-scaffolding. *Jurnal Pendidikan IPA Indonesia* [*Indonesian Science Education Journal*], *7*(2), 181-186. https://doi.org/10.15294/jpii.v7i2.14232

Peñaranda, J. M., Pérez, H. G., & Ortega, M. V. (2020). An approach to the didactics of physics for structural engineering from an artistic perspective. *Journal of Physics: Conference Series, 1674*, 012012. https://doi.org/10.1088/1742-6596/1674/1/012012

Rwamasirabo, A. (2019). *Students' perception on the use of information and communication technology in polytechnics: "A case of IPRC Kigali"* [Master's thesis, University of Rwanda-College of Education].

Saputri, A. A. (2021). Student science process skills through the application of computer based scaffolding assisted by PhET simulation. *At-Taqaddum, 13*(1), 21-38. https://doi.org/10.21580/at.v13i1.8151

Saputri, A. A., & Wilujeng, I. (2017). Developing physics e-scaffolding teaching media to increase the eleventh-grade students' problem solving ability and scientific attitude. *International Journal of Environmental and Science Education, 12*(4), 729-745.

Sarah, L. L., Ananto, Y., Octonary, D., & Nussifera, L. (2022). The implementation of web based e-scaffolding enhance learning (ESEL) on center of mass concept understanding. *Jurnal Inovasi Pendidikan IPA* [*Journal of Science Education Innovation*], *8*(1), 37-46. https://doi.org/10.21831/jipi.v8i1.46476

Shava, H., Chinyamurindi, W., & Somdyala, A. (2016). An investigation into the usage of mobile phones among technical and vocational educational and training students in South Africa. *SA Journal of Information Management, 18*(1), a716. https://doi.org/10.4102/sajim.v18i1.716

Sobirin, M., H, S. K., & Kusairi, S. (2018). Distributed scaffolding influences in inquiry learning on high order thinking skills. *Jurnal Pendidikan Sains* [*Journal of Science Education*], *6*(4), 128-134.

Sözen, E., & Güven, U. (2019). The effect of online assessments on students' attitudes towards undergraduate-level geography courses. *International Education Studies, 12*(10), 1-8. https://doi.org/10.5539/ies.v12n10p1

Susanti, E., Rizal, R., & Sulistyaningsih, D, (2021). Usability of screencast in 1st basic physics lectures during the COVID-19 pandemic: Student's perception analysis. *Jurnal Ilmiah Pendidikan Fisika* [*Scientific Journal of Physics Education*], *5*(3), 459. https://doi.org/10.20527/jipf.v5i3.3903

Ugursal, V. I., & Cruickshank, C. A. (2015). Student opinions and perceptions of undergraduate thermodynamics courses in engineering. *European Journal of Engineering Education, 40*(6), 593-610. https://doi.org/10.1080/03043797.2014.987646

Wan, N. (2014). Flipping the science classroom: Exploring merits, issues and pedagogy. *Teaching Science, 60*(3), 16-27.

Yang, D., Streveler, R., Miller, R. L., Senocak, I., & Slotta, J. (2020). Using schema training to facilitate students' understanding of challenging engineering concepts in heat transfer a thermodynamics. *Journal of Engineering Education, 109*(4), 743-759. https://doi.org/10.1002/jee.20360

Zavala, G., & Dominguez, A. (2016). *Engineering students' perception of relevance of physics and mathematics* [Paper presentation]. The 2016 ASEE Annual Conference & Exposition. https://doi.org/10.18260/p.26664

Zhang, Z., Cao, T., Shu, J., & Liu, H. (2022). Identifying key factors affecting college students' adoption of the e-learning system in mandatory blended learning environments. *Interactive Learning Environments*, *30*(8), 1388-1401. https://doi.org/10.1080/10494820.2020.1723113

Please cite: Uwayezu, J. C., & Renzahoduke, T. (2022). Supporting Construction Technology Students' Outside-of-Classroom Teaching and Learning Physics at One Rwanda Polytechnic College Using a Screencast Application. *Journal of Research in Didactical Sciences*, *1*(1), 12701. https://10.51853/jorids/12701

Received: 28 October 2022 ● Accepted: 11 December 2022

Journal of Research in Didactical Sciences
ISSN: 2997-5905 (Online)

VOL. 1, ISSUE 1, 2022
Article No: 12730

RESEARCH ARTICLE

OPEN ACCESS

An Investigation into Weaknesses Exhibited by High School Students on Biological Drawing

Abigail Fiona Dzidzinyo [1], Ebenezer Appah Bonney [1*], Comfort Korkor Sam [2]

[1] Department of Science Education, University of Cape Coast, Ghana
[2] Department of Science Education, University for Development Studies, Ghana
* Corresponding author: eappahbonney@gmail.com

Abstract: This study was intended to examine the weaknesses biology students exhibit when required to make biological drawings of specimen they are presented with. The explanatory sequential mixed methods design was used for the study. The target population was all SHS 3 students offering biology as an elective in senior high schools in Cape Coast Metropolis of Ghana during the 2020/2021 academic year. The accessible population, however, was elective biology students from six schools in the metropolis. A sample size of 230 students was used. An achievement test and an interview schedule were the research instruments used. Kuder-Richardson-20 value for the achievement test calculated after pilot testing was found to be 0.43. Descriptive statistics such as frequencies and percentages were used to analyse the students' scores on the achievement test, while data from the interview were analysed using themes. Students' weaknesses were on the provision of appropriate headings, avoiding shading, ruling guidelines without arrowheads, and accuracy of features drawn. It was recommended that biology teachers should ensure that the rubrics of biological drawing are at students' fingertips by giving lots of drawing exercises, marking and discussing shortfalls with students.

Keywords: biological drawing, high school students, weaknesses

INTRODUCTION

Biology, the study of life, requires careful observation and description. One excellent way to describe an object is to draw it. The goal of the observer is to move beyond simple, mental images of what he/she believes a particular living thing looks like, and instead concentrate on the unique identity of that specimen (Leslie, 1995). For example, we all have in our mind an image of a tree that might be represented by a child's "lollipop" tree drawing, but most of us have not taken the time to notice subtle differences that characterize each tree.

Oddly, biology teachers spend little or no time on students drawing skills or on how their work will be assessed and graded. As a result, many students are intimidated by drawing exercises and resort to copying drawings from laboratory manuals and textbooks (Dempsey & Betz, 2001; Rogers, 2008). Careful observation and interpretation of nature, both key components of the scientific process (National Research Council, 1996; Dimitrijevic et al., 2016), are lost unless time is devoted to drawing skills. Dimitrijevic et al. (2016) also found that when science students are taught by a team of teachers, including even the art teacher, they tended to do better on biological drawings.

Biological Drawings – Rules and Regulations

Scientific drawings are an important part of the science of biology and all biologists must be able to produce good quality scientific drawings regardless of their artistic ability. Drawings not only allow one to record an image of the specimen observed, but more importantly, they help one to remember the specimen as well as the important features of the specimen.

Drawing a specimen requires one to pay attention to detail so that s/he can recreate it on the sheet. While doing this, the brain is recording these same features in such a way that they can be recalled if necessary (for example in an examination). Simply observing pictures of specimens in a book or on a computer screen is less effective when it comes to remembering and understanding what you observed (Debarati & Gowramma, 2017).

A drawing is said to be a picture or diagram made with a pencil, pen, or crayon rather than paint, especially one drawn in monochromatic mode. The ability to draw accurately and neatly is a useful skill, especially in science (Debarati & Gowramma, 2017). Most artists follow some basic rules to make their drawings attractive and easy to read; and according to West African Examinations Council (WAEC, 2000), the following details are expected in biological drawings:

1. The diagram should be reasonably large.
2. Features should be accurately drawn, maintaining the relative sizes as observed in specimen.
3. Lines should be smooth, unbroken and of even thickness.
4. Guidelines should be ruled and they should have no arrow heads.
5. Guidelines should not cross each other.
6. Guidelines could be of any angle but the labels should be HORIZONTAL (p. 134).

The following are also to be taken cognizance of when making biological drawings:

1. The drawing should cover approximately 1/3 of the page or more.
2. Leave at least a one-inch margin on all four sides of the paper. Keep the drawing to the left of the center.
3. The title of the drawing is simply the name of the object you are looking at. Please use CAPITAL letters and center it at the top of the page (If it is the transverse section, dorsal view, etc. of a specimen, it should be captured in the heading. Also if the drawing is to highlight some aspects of a specimen, it must reflect in the heading).
4. Center the drawing on the page.
5. Labels are to line up on the right hand side of the page.
6. Never use the plural form of a word when pointing to a single object or part.
7. Do not shade or sketch. All lines should be solid and complete. Use stippling in place of shading when necessary.
8. When using the scientific name of an organism in places other than the title, remember that the first letter of the genus or first part of a scientific name is always capitalized. The first letter of the species or second part of a scientific name is not (Iloeje, 1997).

Either one or two drawings can be done on a single page, but never more than two. If only one drawing is to appear on the page, it is to be centered in the upper two thirds of the page. The drawing must be large enough to allow for small details to be clearly shown and labeled.

Students Weaknesses on Biological Drawings

1. Diagrams – drawn out of proportion, labeled poorly, relative position of structures or organelles in most cases were not correct (WAEC, 2000, 2001).
2. Headings of drawings are not done properly (WAEC, 2004).

3. “The major weakness encountered this year is poor diagrams drawn by the majority of candidates. The standard of drawing was generally poor. The drawings of many did not represent grass shoot they were given to draw, and it was impossible to find a drawing with clean lines” (WAEC, 2003). “The standard of drawing was extremely poor” (WAEC, 2005, 2018, 2019).

After the list of Summary of Candidates Weaknesses, a list of “Suggested Remedies” is always given. These are suggestions on ways that the weaknesses noted could be addressed in order to minimize or obliterate the problem altogether. Yet the perpetual exhibition of the same weaknesses every successive year is an indication that those suggestions are not being put into practice.

Biology Teachers’ Competence in Identifying Errors in Biological Drawings

As has been aptly said, it is what a person has that he/she is able to give. In other words, what one lacks cannot be imparted to another. In the light of this, if biology teachers are lacking the skill of making biological drawings, it will be difficult for them to impart such to the students. More so, it will be difficult for them to pinpoint students’ weaknesses (or errors) and help them address same. It is thus significant that Bello’s (2022) study which surveyed Nigerian biology teachers knowledge of errors in biological drawings found out that out of the ten types of errors considered, it was only two that more than 50% of the teachers readily recognized. The remaining eight errors had less than 50% of the teachers recognising them – for one particular error (i.e., drawing without magnification) none of the teachers was able to recognize it as an error.

In a similar vein, Nugraha (2018) assessed biology student-teachers’ competence in making biological drawings of human internal organs. The study revealed that although the student-teachers generally were in level 5 of the 7 levels used for the study, they had difficulties with accurate positioning of organs, proportions and specific details of organs drawn. These are would-be teachers. Thus, if they are exhibiting these weaknesses, it presupposes that, if left unchecked, their future students may also have similar weaknesses with respect to making biological drawings. If biology teachers (or potential biology teachers) are themselves unable to identify errors with biological drawing, then it is not surprising for students to continuously exhibit weaknesses on biological drawings as the chief examiner’s reports consistently point out.

Criteria for Assessing Biological Drawings

1. Accuracy of the drawing - resemblance to the specimen, distinctive biological features, proportion of various parts.
2. Smooth, clear lines and overall neatness.
3. Labels, title and magnification.

Reviewed WAEC Examination Questions on Biological Drawings

Question 1: Make a drawing, 8–10 cm long of the lateral view of specimen F and label it fully (WAEC, 2006).

Comments: This question required candidates to:

(a) make a relatively large drawing (which means that they should devote a whole page to it),

(b) make the drawing at the centre of the page with space on all sides for labeling, and

(c) place labels horizontally.

In short the question is clear and unambiguous, requiring students to observe all the rubrics of biological drawing. It is not above their level either. However, the Chief Examiner reported that for majority of candidates the standard of drawing was very poor. Proportion of parts was wrong, the position of features was wrong and the drawing in many cases was untidy. It was further reported that the style of labeling marred an already poor substandard drawing. Many candidates failed to place labels horizontally and used the plural forms in naming single features.

Question 2: Draw and label a diagram of the transverse section of a dicotyledonous leaf as seen under the low power of the microscope (Presentation of cells not required, WAEC, 2001).

Comments: With this question, candidates were required to draw the low power view of the transverse section of a dicotyledonous leaf. The instruction on the question paper that "Presentation of cells not required" was most appropriate since it makes the question quite precise, warning students not to draw textbook diagram of the transverse section of a leaf. Yet in spite of the warning, the Chief Examiner still reported that many candidates drew the textbook diagram.

Purpose of the Study

The study examined specific weaknesses exhibited by SHS 3 elective biology students on biological drawings, and the reasons accounting for the exhibition of the weaknesses.

Research Questions

The following research questions guided the study:

1. What specific weaknesses are exhibited by SHS 3 students on biological drawings?
2. What reasons account for students' weaknesses on biological drawings?

Significance of the Study

The study findings will be of much benefit to teachers. This is because it enlightens biology teachers on the various weaknesses their students exhibit in the making of biological drawings. It is also of significance to biology students since it would help them identify their own strengths and weaknesses on biological drawings. The West African Examinations Council will equally benefit if it gives consideration to the information on the dissemination and use of their Chief Examiner's reports by teachers, in order to strive to find the best means of ensuring that those the reports are intended for are accessing them.

RESEARCH DESIGN

The explanatory sequential mixed methods design was used for the study. Data collected was used to describe the nature of SHS biology students' difficulties with biological drawings, as well as to investigate details of the recurrent weaknesses found in SSSCE candidates' scripts with regards to biological drawings, their difficulties associated with drawing, and the reasons why they exhibit such weaknesses.

A one shot achievement test was given and was followed right after with focus group interview (that is, after the papers had been scored and those who made the mistakes had been identified). Also the risk of non-response associated with the use of questionnaires and others was not encountered as intact classes of SHS 3 elective biology students were used and scripts collected on the spot.

An achievement test formed the first stage of the study. The second stage involved focus group interviews of students who exhibited the weaknesses reported on by the chief examiners. The teachers of these students were also interviewed one-on-one afterwards using the structured interview guide. This was done to solicit responses from both the students and the teachers on reasons for the making of mistakes noted on the achievement test. The information obtained from the interviews helped describe and interpret what was observed as the reasons for students' weaknesses in the areas concerned (Best & Kahn, 1989).

Population

The target population was all SHS 3 students offering elective biology in Cape Coast Metropolis during the 2020/2021 academic year. However, the accessible population was elective biology students from seven schools in Cape Coast Metropolis. The accessible population consisted of 939 students.

Sample and Sampling Procedure

A multi-stage sampling technique was employed to select six schools, six classes, six teachers and 230 students. There are eight public senior high schools in Cape Coast Metropolis which offer elective biology. Two of the schools are single-sex female (SSF) and were selected conveniently. Three are single-sex male (SSM) schools, and using computer generated numbers, two were randomly selected to participate in the study. The remaining three are co-educational (CE) schools. As such two of these were also randomly selected to be part of the study. All the four single-sex (SS) schools are Category A schools whereas the two coeducational schools are both Category B schools. These categories are assigned depending on the available facilities and not according to academic performance.

At each school an intact class was randomly selected (using computer generated numbers, obtained from Microsoft Excel) and used since each of the six schools had more than one science class (both CE schools had three science classes each, while one SSF school had five, one SSM had four, with the remaining two SS schools (one SSF one SSM) each having three science classes).

Of the two intact classes selected from the two SSF schools one had 35 students and the other consisted of 32 students. However, of the classes selected from the SSM schools one was made up of 40 students and the other of 41. The classes selected from the CE schools were made up of 46 (that is 29 females and 17 males) and 36 students (14 females and 22 males). In all a sample size of 230 students was used. In all the schools the intact classes can be said to be equivalent in terms of numbers, since the differences in the number on roll were just plus/or minus five. Overall, the sample was made up of 110 females and 120 males.

For the focus group interviews, in each school, students who were identified as having exhibited the documented weaknesses on the achievement test were singled out and organized for the interviews. (In four of the schools, all the students in the classes selected were involved in the focus group interviews). The six teachers whose classes were sampled and used for the study were purposively selected and interviewed one-on-one.

Validity of the Instruments

The face validity of the achievement test was determined by giving copies of the test to experts in biology education in the Department of Science and Mathematics Education of the University of Cape Coast for their perusal and comments. A biology teacher in one of the schools was also given a copy for comments on any ambiguities, confusing terminologies or statements. Comments and inputs from the experts were used to fine-tune the test into the final one used for the actual study.

The content validity was ascertained by using the biology syllabus as a form of table of specification to check whether the questions covered all aspects in biological drawings as stipulated.

The construct validity was assumed since the questions were all culled from past WAEC SSSCE biology papers (all WAEC examination questions are supposed to have gone through various tests of validity as a team of experts in assessment are employed to check all that).

For the interview schedule, only the face validity was considered. This was done by giving copies to experts of biology education in the Department of Science and Mathematics Education of the University of Cape Coast. They read through and gave their comments. After making the required changes (such as changing in wording), the schedule was used for the study.

Reliability of the Instruments

The instruments were administered as a pilot test to a school in Cape Coast Metropolis which was not used for the actual study. A marking scheme was developed for scoring the items dichotomously. The inter rater reliability coefficient was found to be 0.93. Kuder-Richardson-20 (KR-20) was used to determine the reliability of the other items which were scored objectively. The KR value for the drawing was $r = 0.43$.

Data Analysis

Both quantitative and qualitative analyses were employed in this study. Quantitative analyses were used to analyze the results from the achievement test in the form of descriptive statistics such as frequencies and percentages. The qualitative analysis was used for data from the interviews where the responses were pure descriptions.

A marking scheme was prepared for scoring the BAT items. The scoring, in the most part was done in the form of a checklist, where a mark was given for the required competency indicated and '0' was for absence/incorrect competency demonstrated.

To answer research question one, descriptive statistics (such as percentages and frequencies) were used. The frequencies and percentages of students who failed to exhibit the competencies required were then compared, and

Table 1. Frequencies and percentages of students' weaknesses on biological drawing (N = 230)

Competency	Frequency	Percentage (%)
Wrong/missing heading	179	77.8
Size of drawing less than 1/3 of page	38	16.5
Drawing lines rough, broken, of uneven thickness	24	10.4
Any form of shading	60	26.1
Guidelines of labels not ruled, having arrowheads	64	27.8
Orientation of labels not horizontal	17	7.4
Inaccurate features drawn	129	56.1

the areas where students failed most (i.e., where more than 20% of students had it wrong) were considered to be the most difficult ones and were therefore labeled as the specific weaknesses of the students.

The descriptive statistics were most appropriate since it helped pinpoint students' specific weaknesses with drawing. Responses from the interview were analysed thematically and used to explain students' answers on the test. To help answer research question two, a pure description of both the teachers and students' responses on the interviews were given thematically. This was most appropriate since the interview responses were used for this.

RESULTS

Research question 1 sought to find the specific weaknesses students have on biological drawings. To answer this, students' scores on the BAT were analysed using frequency counts of the competencies that students were required to exhibit. The percentages of students who had the individual competencies were then calculated. The results are presented on **Table 1**. From **Table 1**, it can be seen that four of the competencies (*Wrong/missing heading*, *Inaccurate features drawn*, *Guidelines of labels not ruled, having arrowheads*, and *Any form of shading*), proved to be very difficult for the students.

This is because each of these had a percentage above 25, with Wrong/missing heading being the most difficult for students as 77.8% of the students did not exhibit that competency. With the remaining three competencies (Size of drawing, Drawing lines, Orientation of labels not horizontal), less than 25% of students had them wrong. This is an indication that these areas are not too difficult for the students.

The specific weaknesses of students on biological drawings from the study were:

(1) difficulty with providing an appropriate heading,

(2) shading,

(3) not ruling guidelines as well as using arrowheads, and

(4) drawing inaccurate features.

Reasons Why Students Exhibited the Weaknesses Noted

The second research question sought to find out the reasons accounting for students' weaknesses with regards to biological drawings. Data from interviewing a cross-section of the sampled students (six from each school, totaling 36) and six teachers (one from each school), were used to answer this question. These were presented thematically as follows: Biological drawing, Provision of an appropriate heading, No shading, Guidelines ruled with no arrowheads, Accurate features drawn.

Biological drawings: According to the Chief Examiners, candidates continue to display weak drawing skills and lack of knowledge of the conventions of biological drawings, such as the inclusion of magnification and titles of the drawings. In addition, far too many candidates present untidy drawings with crooked labeling lines (WAEC, 2004). The reasons given by students as to why they fell short on the biological drawing are presented in themes as follows.

Students Views on Why They Made Mistakes on Biological Drawing

Provision of an appropriate heading: While 17 of the students said they wrote the name of the flower for the heading thinking that was what was required, the rest said they forgot to provide a heading. For those who thought writing the name of the flower suffices for the title of the drawing, it appears that is what they have been doing with the biological drawings they have been making in school.

No shading: 21 of the students shaded because they wanted some parts of the drawing to stand out. The remaining 15 students said they had seen some drawings in textbooks with parts shaded and thus they thought it was alright to do same.

Guidelines ruled with no arrowheads: On ruling guidelines with the free hand, and adding arrowheads, 17 of the students thought how the guidelines was made was irrelevant, only the correct label was needed. Four of them forgot to rule the lines because they were in a hurry. Still 15 of them were imitating the teacher who uses the free hand in making guidelines on the writing board.

Accurate Features Drawn

On their inability to draw accurate features, all the students said it was because they simply are not good at drawing. Also they said drawing is difficult for them, thus they drew anything to represent what they saw.

Teachers Views on Why Students Made Mistakes on Biological Drawing

Teacher' views on why students exhibited weaknesses on the drawing are presented in themes below.

Provision of an appropriate heading: Three of the teachers said students' laziness is the reason why they did not provide any heading for the drawing; or did it wrongly. The remaining three teachers said they could think of no reason why the students should not provide an appropriate heading for the drawing since they had taught them that it is very important.

No shading: While four of the teachers could not give any reason why the students shaded their drawings two of them said some students are just plain stubborn. No matter what you say or do, they will always make that mistake. They are just irresponsible.

Guidelines ruled with no arrowheads: All the teachers interviewed said the students did not rule the guidelines for the labels and some went further to add arrowheads due to simple negligence. They could not give any other reason for this since they said they had taught them the correct thing to do.

Accurate Features Drawn

In confirmation of what the students said as to why they could not draw features of the specimen accurately, all the teachers also said some students find drawing difficult. Thus, they just draw anything to represent what they see. Furthermore, during the interviews, when asked whether they used the Chief Examiners' reports to inform their teaching, all the six biology teachers interviewed responded in the negative, giving varied reasons. The first teacher said she did not because she could not lay hands on them the few times she tried. According to her, those in authority kept the reports to themselves and it was futile searching for them. The second teacher, on the other hand, did not use the reports because he could not get the current issues. He attributed this to the fact that WAEC tends to release the reports about three years after the examinations had been taken.

The third teacher does not use them because she feels the syllabus is alright for her in ensuring that she teaches the students what is required for the examinations. To her, if a teacher is able to complete the syllabus with the students before they sit the examinations, it should be enough for the students to perform creditably.

The fourth teacher admitted not having considered the matter. He thus agreed that it would be quite beneficial to the students if he consults the reports, at least, from time to time.

Teacher number five was of the view that if WAEC wanted them to use them in their teaching they would release the reports to the schools on time. Thus he also did not use the reports because he finds them redundant.

Teacher number six, however, occasionally used ideas from them when prompted to do so by the Head of Department. Otherwise he rarely used it on his own initiative.

DISCUSSION

The results on the research question one pinpointed four competencies that students find very difficult. These were labelled as the specific weaknesses students have with biological drawings, namely, *Wrong/missing heading*, *Inaccurate features drawn*, *Guidelines of labels not ruled, having arrowheads*, and *Any form of shading*. All these weaknesses have been cited frequently by the Chief Examiners as specific weaknesses of students. For instance, both the 2000 and 2001 WAEC chief examiner's reports indicated that candidates who sat for biology in those years, drew diagrams that were out of proportion, labeled poorly, had the relative position of structures or organelles in most cases incorrect. The latter meaning that the candidates drew inaccurate features. The poor labeling of drawings reported by the Chief Examiners included using the free hand to make guidelines, giving guidelines arrowheads, as well as not orienting labels horizontally to the top of the page. All these weaknesses were observed in the students' scripts. With shading, some students may feel justified since some features need to be made to stand out. However, in such cases stippling (i.e., using dots) is recommended, instead of any form of shading (Iloeje, 1997).

The results from answering research question two indicated that the reasons given by both students and teachers for the exhibition of the specific weaknesses exhibited on the biological drawing were varied. Whereas some of the reasons from the two parties overlapped, others were at variance. For instance, on the provision of heading, whereas students said they thought writing the name of the specimen drawn sufficed because that is what they had been doing in class, the teachers said they had taught the proper thing to do. In this instance, since no correction of the mistake had been made by the teachers, the students had taken it to be the correct practice. [The biology syllabus advises teachers to help students practise giving appropriate headings to biological drawings in class when teaching biological drawings (Ministry of Education, Science and Sports, 2008)]. If the teachers are able to do so, such mistakes will not be repeated on external examinations like the SSSCE/WASSCE.

On the no shading competence, students said they shaded because they found such in textbooks or they felt they had to make portions of the drawing stand out by shading. This is not surprising since some students even copy textbook drawings when they are required to observe the specimens and draw them. This may mean that either the teachers are not telling them not to shade their biological drawings, or they have been taught but they stubbornly stick to what they consider to be right, where students have to make some parts stand out on the drawing it is recommended that stippling be used (stippling refers to the use of dots to distinguish between parts on a drawing). Apparently the students were not aware of any such thing and thus felt justified in using shading instead. The teachers, however, on this subject attributed students' weakness to stubbornness or irresponsibility.

With regards to not ruling guidelines with a rule, a section of the students said they were imitating their teachers who tended to rule guidelines with the free hands on the board. This group of students do have a case on the point. It is well known that students emulate teachers in what they do, especially when it comes to how they present information to the students. Thus the teachers should practice what they teach the students in class. When they make any drawing on the board and have to label, they should use the chalkboard rule to make the guidelines. The teachers, however attributed this weakness simply to negligence on the part of the students. Since the students do not agree with the teachers on this, it is possible that the teachers do tell the students to use rulers, but contrary to what they say, they (the teachers) use the free hand when demonstrating it on the chalkboard. Thus, since we learn best by imitating, students copy what they see the teacher doing and somehow unconsciously ignore what the teacher tells them.

On the competence of drawing accurate features both teachers and students agreed that students simply lack that skill. However, such students should not be left to their own whims and caprices. They need to be helped to draw by helping them practice constantly. This could be achieved when the teacher gives students a lot of practical exercises that include drawings. This is quite necessary because drawings are obligatory in biology (WAEC, 2000).

A look at the weakness and reasons for their exhibition by students shows that if teachers consult chief examiner's report and use the prodding therein, it will go a long way to forestall most, if not all, of the weaknesses. However, teachers reasons for not using the reports are quite worthy of note. In a nutshell, some biology teachers do not use Chief Examiners reports to inform their teaching for varied reasons. Some of the reasons are as follows:

a) the reports are not available when needed,

b) late release of reports making them redundant,

c) not necessary, the syllabus is enough, and

d) the importance of the reports has not been considered.

If teachers who are supposed to be using the reports in their teaching are not getting them to use, then the information provided can be said to be going to waste. Indeed, the Chief Examiners' reports are actually addressed to the teachers. In most cases the examiners specifically state: 'teachers should …' indicating that the report is specifically for the information of the teacher.

In the past, many people in our part of the world were not too concerned with expiry dates. However, in recent times people are now much aware of the significance of expiry dates. Thus, when something is said to be old, many do not pay much attention to it. As such it will be expected that Chief Examiners' reports for a particular year should be released together with the results of the year to be deemed current by the prime users, i.e., teachers. Failure to release them on time may lead some to view them as somewhat 'outmoded', or 'expired'.

The importance of the reports should be made very clear to both teachers and students, (especially to the teachers). Also it should be emphasized to the teachers that no matter how old a report is, once it is on your subject/area, they need to be reviewed and the information therein used to supplement the teaching. For instance the weaknesses that are pointed out in every report could be most enlightening. When considered they will help a teacher to know aspects of topics that need to be hammered or given more attention. It will also help the teachers to better prepare the students for the examinations. Indeed, teachers should combine the Chief Examiners' reports with the syllabus to ensure their students are well prepared for the WAEC examinations.

CONCLUSIONS

It was the objective of this study to examine specific weaknesses exhibited by SHS 3 elective Biology students on biological drawings in the light of what WAEC Chief Examiners have been reporting. Also, the study investigated the reasons for the exhibition of the weaknesses students had on the biological drawing.

The study confirmed what the literature report to be the weaknesses of students on biological drawings. According to literature, biology students' weaknesses on drawings include diagrams drawn out of proportion, labeled poorly, with relative position of structures or organelles in most cases not correct. However, in addition to what the literature report to be students' weaknesses on biological drawings, the study found out that students had the most difficulty with providing an appropriate heading for the drawing, avoiding any form of shading, and making ruled guidelines with no arrowheads.

The findings of the study are of much importance to teachers. This is because they serve as enlightenment for biology teachers on the various mistakes their students make in the areas of biological drawings. They are also of significance to biology students, since they help them identify their own strengths on biological drawings and address them to the best of their knowledge.

Recommendations

Biology teachers and their students should go the extra mile in ensuring that the rubrics of drawing are at students' fingertips. Teachers can do this by giving students lots of exercises on drawing and ensuring that such exercises are marked and discussed in class with students.

Limitation of the Study

The use of only self-report data on the part of the teachers involved in the study may be said to be the limitation of this study. Their responses on the interviews with respect to what they actually taught the students on the rubrics of biological drawings were not corroborated with first-hand information from classroom observations. Even though, asking students similar questions during the interviews and comparing their responses were intended to help triangulate the data, if teachers actual practice had been observed and compared with what was self-reported, it would have been laudable. It is thus suggested that a future study should include classroom observations to look into how teachers teach biological drawings.

REFERENCES

Bell, J. F. (1999). *Investigating gender differences in the science performance of sixteen-year-old pupils*: *University of Cambridge local examination syndicate* [Paper presentation]. BERA, University of Sussex, Brighton.

Bello, G. (2022). Assessment of Nigerian biology teachers knowledge of errors in biological drawing. *Aquademia, 6*(1), ep22004. https://doi.org/10.21601/aquademia/12183

Best, J. W., & Kahn, J. V. (1989). *Research in education* (6th ed.). Englewood Cliffs: Prentice Hall, Inc.

Debarati, D., & Gowramma, I. P. (2017). An analysis of students' drawings and labelling skills in science at the elementary level. *Indian Educational Review, 55*(2), 108-123.

Dempsey, B. C., & Betz, B. J. (2001). Biological drawings: A scientific tool for learning. *The American Biology Teacher, 63*(4), 271-272. https://doi.org/10.2307/4451099

Dimitrijevic, J. D., Filipovic, S. B., & Stanisavlijevic, J. D. (2016). An analysis of students' drawings for purpose of considering the efficiency of teamwork (Programme content: Marine life community). *Journal of Subject Didactics, 1*(1), 25-38.

Iloeje, S. O. (1997). *Senior secondary certificate practical biology*. Lagos, Nigeria: Academic Press P/C.

Leslie, C. W. (1995). *Nature drawing: A tool for learning*. Dubuque, IA: Kendall/Hunt Publishing Company.

Ministry of Education, Science and Sports. (2008). *Teaching syllabus for elective biology*. CRDD, GES, Accra, Ghana.

National Research Council. (1996). *Inquiry: National science education standards*. Washington, DC: National Academy Press.

Nugraha, I. (2018). The use of drawing as an alternative assessment tool in biology teaching. *Journal of Physics: Conference Series, 1013*, 012016. https://doi.org/10.1088/1742-6596/1013/1/012016

Rogers, M. (2008). Learning by drawing. *Symmetry Magazine*. http://www.symmetrymagazine.org/breaking/2008/05/21/learningbydrawing

WAEC. (2000). *Chief examiner's report on senior secondary school certificate examinations.* Accra: Wisdom Press.

WAEC. (2001). *Chief examiner's report on senior secondary school certificate examinations.* Accra: Wisdom Press.

WAEC. (2003). *Chief examiner's report on senior secondary school certificate examinations.* Accra: Wisdom Press.

WAEC. (2004). *Chief examiner's report on senior secondary school certificate examinations.* Accra: Wisdom Press.

WAEC. (2005). *Chief examiner's report on senior secondary school certificate examinations.* Accra: Wisdom Press.

WAEC. (2006). *Chief examiner's report on senior secondary school certificate examinations.* Accra: Wisdom Press.

WAEC. (2018). *Chief examiner's report on West African secondary school certificate examinations.* Accra: Wisdom Press.

WAEC. (2019). *Chief examiner's report on West African secondary school certificate examinations.* Accra: Wisdom Press.

Please cite: Dzidzinyo, A. F., Bonney, E. A., & Sam, C. K. (2022). An Investigation into Weaknesses Exhibited by High School Students on Biological Drawing. *Journal of Research in Didactical Sciences, 1*(1), 12730. https://doi.org/10.51853/jorids/12730

Received: 06 October 2022 ● Accepted: 18 December 2022

Journal of Research in Didactical Sciences
ISSN: 2997-5905 (Online)
VOL. 1, ISSUE 1, 2022
Article No: 12733

RESEARCH ARTICLE
OPEN ACCESS

The Factors that Affect Mathematical Achievement Among High School Students

Serkan Kaymak [1*], Aidyn Sautkali [1]

[1] Suleyman Demirel University, Kazakhstan
* Corresponding author: serkan.kaymak@sdu.edu.kz

Abstract: This study was conducted to examine different factors that affect mathematical achievement among high school students in Kazakhstan. The respondents for this study were 8th and 10/11th grade students (36 girls and 22 boys). A survey was conducted by using a questionnaire for information gathering about different factors relating to mathematics achievement of students. The mathematics performance was gauged by the result of their 3rd algebra and geometry quarter grades. The findings indicate that there are positive relationships between teacher factors and student self-confidence attitude with mathematical achievement. The outcomes of correlation analysis show student's attitude is the significant predictor of mathematical achievement ($r = 0.424$, $p < .001$) followed by teacher support ($r = 0.397$, $p < .001$).

Keywords: mathematics achievement, quality performance, factors

INTRODUCTION

Background Information

Education has a special place in the economy. A well-educated generation contributes to economic stability and creates opportunities for all citizens to succeed and find their place. Through the acquisition of knowledge, we can influence, study and develop our environment. This normalizes the search process. It has a great impact on personal and spiritual development. Learning is a continuous process, we can learn great lessons through every victory and defeat in our lives, we can discover new things by learning a lot from the people who lead us and help us. The great sage Abai, in his 17th wisdom words, said that the three of strength, mind and heart should be kept together, that is, these three elements in the path of human knowledge have a significant impact. According to other scientific work, a student begins to learn quickly if the student is directly involved in the learning process, that is, if the learner constantly moves on the way to achieve results (Bhardwaj, 2016). According to the OECD (2019_III), the influence of the teacher on the student is huge. True professionals influence their students, ensuring that their attention is focused only on learning. In this regard, the teacher is not only responsible for the atmosphere of learning in the classroom, but also directly involved in the motivation of students. By enabling students to set the right goals for learning and to participate with them equally, this is a positive achievement for students. Another thing to note is that when the student's interest in the lesson and the teacher's motivation go hand in hand, it helps to reach new heights quickly and effectively. Based on this study, it can be seen that students who show good results become more motivated. It turns out that the student's energy and attitude to mathematics leads to success (Afzal et al., 2010). It turns out that a student's personal factors and academic success also depend on school activities. Where there is a desire for progress and continuous development, there are good opportunities for students (Lee, 2014). There is a link between school discipline and academic achievement, disciplined schools, with a focus on learning, achieve a high level of performance (Shin et al., 2009).

Statement of the Problem

The focus of this research is to identify the factors that affect mathematics education success at high school in Kazakhstan. To achieve this, a survey will be conducted in schools. Previous research has demonstrated that factors that students factors, teacher factors, parents background and schools factors have significant influence on mathematics education success at school (Demir et al., 2009). The study, conducted with 3,765 15-year-old students in 158 schools in Turkey, examined the impact of factors on student background, learning strategies, individual abilities, and the school climate. Based on this research, the parents of students have a significant influence on them, that is, they influence their future enrollment in university and finding their place. If the student has a low level of anxiety and his mathematical ability leads to mathematical success. For example, OECD states that all school climate factors are important for students' academic outcomes. The author of this study investigated the factors that have the greatest impact on students' PISA 2018 scores. Teacher and parental influence are statistically significant factors. However, the data used to assess reading, science, and mathematics performance (Akhmetov, 2021). So, in this study, we looked into the factors that influence mathematics scores. The more recent 2018 PISA data provides a useful way to explore the role that school climate might play in improving academic outcomes in Kazakhstan.

Purpose of the Study

The purpose of this study is to identify the factors that affect mathematics education success at high school in Kazakhstan. Identify the factors that affect the achievement of mathematical knowledge of students by discussing and studying the impact of the above factors on the success of mathematical knowledge. As a recommendation, all of the above factors should be taken seriously in order to maximize mathematical achievement. Identify the factors that lead to a local outcome

Therefore, this study has two objectives (research questions), as follows:

1. To determine the factors that affect mathematics education success at high school.
2. To determine the largest predictor that influences the mathematical achievement of high school students.

Significance of the Study

There are very few scientific studies in Kazakhstan that study the factors that affect the mathematical success of students. By studying the factors that have a high impact on this, the learning situation in schools, the training of world-class strong teachers and the impact of students' mathematical success Based on the objectives, we investigated the following hypotheses:

1. Hypothesis 1 (**H1**). There is a significant relationship between mathematics success at school and student self-confidence attitude.
2. Hypothesis 2 (**H2**). Student self-confidence attitude, teacher support and class learning environment are predictors of the mathematical achievement of high school students.

LITERATURE REVIEW

Young people's enthusiasm for reading should be nurtured beginning in childhood and continuing into adulthood. The number of books a student owns is also an indicator of his or her socioeconomic status (SES). Lack of confidence can reduce the number of students who can continue their education or work in jobs that require mathematics knowledge and skills (Azina & Halimah, 2012). The influence of a child's family background on educational achievement remains significant. Children from affluent families attend better schools than children from low-income families. Parents with low socioeconomic status are less able to afford the costs of their children's higher education (Rouse & Barrow, 2006). This research conducted a study of 100 students to find out the effect of the student's situation at home on mathematical achievement. It depends on the number of people in the house to instill the values and views of parents. The social status of the parents had a significant impact on the child's mathematical progress. Parents are more likely to encourage their children's academic success. Students who receive support and motivation from their families outperform their peers from unsupportive families in school. This means that if a parent has a high level of education, they can guide the child in a timely manner and tell them about the importance of learning, which in turn leads to mathematical success (Oginni, 2018). The majority of experts agree that low SES has a negative impact on academic achievement because basic needs are not met, and as a result, they do not perform better academically (Adams, 1996). Parental education and the level of family socioeconomic status are positively correlated with the quality of student achievement (Farooq et al., 2011). Low parental SES has a negative correlation with student performance. The relationship between the student's parental relationship and mathematical achievement was studied from 2,866 students. As a result, the student's parents had a positive effect on their child's mathematics performance if they paid attention to their child's learning and took concrete steps to improve their child's progress. It was observed that the close relationship between the student's parents and the child increases the student's self-confidence (Huang et al., 2021). The study was conducted in 21 countries to find a link between parent-child communication and academic achievement. A special place is given to the attention of parents to their children's learning. There is also the influence of parents on the student's attention to the lesson. Based on the results of 21 countries, each country has a different cultural and economic status of the family, which contributes to academic achievement through social and cultural communication between parents and students. The student showed that it is important to be able to ask for help from their parents in a timely manner and to create conditions for their parents to study (Hampden-Thompson et al., 2013). The higher the socioeconomic level of the student's family, the higher the educational expectations of the parents. When a parent with a high social and economic level has access to the necessary materials and resources for his or her child to study, they set high standards for his or her child to achieve his or her goals. And a student brought up in a social and economic family often does not lead to academic success, as such opportunities and requirements for academic achievement are low (McLoyd, 1989). According to this study, according to the author, the profession of the parents affects the choice of profession of the student when entering the university. For example, if the parents have a high socioeconomic status, then the child chooses a high-paying job in order to reach that level (Leppel et al., 2001). As for the next study, the knowledge of the student's parents has a direct impact on the child's academic achievement. It is important to monitor your child's learning and provide adequate support.

School Climate

Children spend a lot of time in school settings communicating with teachers, students, and other people. Therefore, it seems reasonable to assume that school environment and student peer support could also influence academic achievement and educational expectations of students. In this section, I will analyze the research studies in the literature that have attempted to investigate the relationships between school environment and students' mathematics achievement. Literature consistently suggests that the school environment has a great influence on students' academic performance and educational expectations. If the quality of the material and technical base of the school is high, then it shows a positive relationship between the motivation and results of students in the school. The high level of learning atmosphere in the school shows that the school is related to the quality of its construction. Higher levels of student achievement are associated with higher quality climates and in a low quality/working climate school setting, high student achievement scores appear impractical (Shindler et al., 2016). Based on this research, there is a low level of correlation between the general state of construction of the school and the academic achievement of students (Shouppe & Pate, 2010). Cooperation and competition at school are important for the student. According to Shouppe and Pate (2010), the role of school cooperation in the development of student achievement is more important than competition. The cooperation showed a high level of results if it was covered for a short period of time. This is the result of all disciplines. In other words, cooperation and competition in education complement each other and achieve a harmonious relationship (Tauer & Harackiewicz, 2004). In this study, the student's academic performance was linked to the reason for being closer to school. In the study, the higher a student's academic performance, the higher their affinity for school. As a result, the climate at school affects the student (Huebner & Gilman, 2006). The impact of student intervention on academic achievement was studied. In the 2003 PISA survey, 29,983 students from 1,124 schools in Mexico participated. The search goal is to show the effect of student proximity to school. As a result, PISA scores were higher in each area if the student was closer to school. It is not only the influence of one factor, but also the social status and marital status of the student. Another interesting fact is that if a student is in contact with a teacher, his / her school performance is low. The author intends to study this situation for the future (Weiss & García, 2015). According to this research paper, the use of new approaches that lead to change in school leaders has a positive impact on the development of the school. The teacher's closeness to the school and deep connection with other teachers, it provides to focus on work. The success of a school is due not only to the success of the teachers who work at the school, but also to the leaders who are able to guide the people of the school and make the right strategic decisions. The school leader leads to a positive school climate by guiding and motivating teachers. It is important for school leaders to be open to new things and to create a creative environment for teachers. Therefore, school leaders need to be leaders who push their schools forward and lead to change, which in turn influences teachers, which in turn contributes to students' academic achievement (Allen et al., 2015). The goals set by the school leaders, if consulted with their subordinates, will affect the climate of the environment. Influencing teachers by taking the right steps to achieve the goals set by school leaders, which in turn contributes to the learning of their students (MacNeil et al., 2009). According to the study, the importance of the school climate is well documented. According to the author, one of the most important factors influencing academic achievement is the school factor, and the school climate that affects it. It showed that there is a link between students' negative or positive thoughts about school and their academic performance and also this study identifies anti-bullying attitudes among students as a school climate-related predictor of student achievement (Akhmetov, 2021). The belief that students can succeed in school, the active participation of parents in school activities, the participation of students in extracurricular activities, such steps contribute to a positive school atmosphere (Haynes et al., 1997). According to a study of 380 students, the author studied the social factors of the student at school. As a result, it became clear that the social ability of the student increases the motivation to learn. In other words, in case of difficulties in learning, a student with a developed social ability, in time to ask his classmates and solve the problem. According to research, a student's social skills have a huge impact on academic success (Magelinskaitė-Legkauskienė et al., 2016). By being in school, students are able to communicate with other people and develop themselves intellectually (Webster-Stratton & Reid, 2004). According to this research, 158-year-old students from 158 schools studied the impact of the school climate on academic achievement, and it is necessary to try to avoid the negative conditions in school in mathematics - in education (Demir et al., 2009). In this study of 2,105 students, the teacher-school level showed a link between students' mathematical achievement. The variance of class and school levels is influenced by the initial intellectual level of students and the social status of the family at home, and the interaction of students and proactive teachers, whose mood is focused on learning, has a synergistic effect. The methods used by the teacher in the classroom proved to be important. The author said that there is a positive connection between the opportunity given to the student and his desire to learn. And the teacher's perception of each student as an individual has a great impact (Opdenakker et al., 2002). According to another data, the student's social orientation and academic achievement were correlated. According to him, high-achieving students, in most cases, had a good social status, that is, in case of difficulties in learning, they immediately found an effective way to solve their problems by asking other advanced students for material they did not understand. Students with low communication skills show that they are not able to solve problems effectively in group work (Caprara et al., 2000). Social competence is a combination of the ability to communicate with other students, to benefit another person and to solve problems. Many scholars have studied the relationship between this social competence and academic achievement. The Ministry of Education and Science of the Republic of Kazakhstan focuses on improving the status and professional competence of teachers in the country. In 2016, the Ministry of Education and Science began updating the school's assessment and curriculum to develop students' critical thinking skills. According to the results of our students who participated in PISA in 2009, they showed a very low level of functional literacy. This means that our students will not be able to design and develop the necessary elements based on the information provided.

Teacher Factors

Mathematics achievement is dependent on effective teaching and teacher pressure to succeed. The teacher is the most important factor influencing student learning. If the teacher is ineffective, students under his or her supervision will make unsatisfactory academic progress. It doesn't matter if the students are the same or different in terms of individual potential in academic achievement (Sanders et al., 1997). The teacher's motivation for the lesson influences the students' positive attitude towards the teacher, as a result of which the student feels connected to the school and the mood for learning (Frase & Sorenson, 1992). According to the author of this study, the motivation of students to teach is higher than the enthusiasm of the teacher for the subject. In other words, the teacher talked to the students during the lesson, got to know them well and did his best to make the learning process interesting. Thus, in order for a teacher to feel good in the school environment, it is important to appreciate their work and help them reach new heights (Peterson & Deal, 1998). By updating the members of the administration who lead the school to develop the atmosphere in the school and create a positive environment, we can not only have a positive impact on students, but also help them improve their academic success (Peterson & Deal, 1998). In this study, the teacher's actions were considered. To see the results of the study, students were tested before and after. The results of the last test were good, and the teacher was able to show his abilities in a positive way, which affected the outcome of the study (Solomon et al., 1964). The study examined this relationship between teacher behavior and student behavior. According to the study, the teacher's actions are considered as a consequence, looking at the behavior and actions of the student in the classroom. Teachers have different views on the difficulty of the student's learning. For example, the study looked at the causes of a teacher's aggressive and compassionate behavior. As a result, the teacher treated students with low achievement and little effort. The implication is that teachers' performance is different, with students behaving differently and pushing forward in order to improve their academic performance (Georgiou et al., 2002). The study looked for a link between teacher behavior and student achievement. As a result, when the teacher's actions are active and comprehensive, they affect the student's learning outcomes (Kyriakides et al., 2009). 153 teachers were asked about the background and methods used in the classroom. The teacher's gender does not affect my academic performance, and if the teacher's working hours are excessive, it affects the quality of work, resulting in poor attention to students and the quality of education. The study also concluded that the frequency with which teachers issued assignments provided that the students completed the assignments, as well as the timely assessment of the assignments, had a significant influence on academic progress. As a result, teacher characteristics and classroom teaching methods have an impact on students' academic performance (Kimani et al., 2013). The results of the work on the teacher factor from 2,404 students were, as follows. The use of traditional methods by mathematics teachers in the classroom proved to be effective, and another observation was that the teacher's gender did not affect student achievement. A teacher's educational qualifications are not a guarantee of excellent student achievement. There is no significant relationship between teachers' academic qualifications and student achievement (Haider & Hussain, 2014). In Singapore, the main focus is on professional development for teachers. In this regard, teachers are able to solve their problems not only in a certain direction, but also creatively, that is, students gain knowledge through play. In addition, journal writing is a great opportunity to participate in extracurricular research. This strengthens the connection between the student and the teacher (Tahar et al., 2010).

Student's Attitude

It can be seen that the students' analytical approach to the problem is not related to their gender. When a student uses his energy and intelligence in both ways to solve a problem analytically, the achievement of mathematics plays a significant role. When a student comes to solve a problem with great enthusiasm, it contributes not only to the current situation, but also to the future (Mohd et al., 2011). According to the author of a study of 1,719 students from middle to high school, students with average grades in mathematics had a positive attitude toward mathematics. Internal factors, such as motivation, confidence, interest, depending on the competence, affect the adolescent's attitude to learning. Thus, based on this research, motivated students will have higher achievement and attitudes in mathematics. In many cases, a student's self-confidence leads to good results, that is, as the student's success increases, his attitude to the subject becomes more positive.

In addition to the teaching experience, teachers influence students' motivation by conveying general learning ideas and creating an environment in which each student can help the group during the lesson. If the student is motivated to learn, it indicates not only a low level of motivation, but also a decrease in confidence and ability to solve the problem. Students with high mathematical achievement showed a positive attitude to the subject, and students who are not close to mathematics showed a low attitude to the subject. In this study, the importance of the teacher in learning is discussed. In mathematics class, the teacher gives the students the right tasks and the words they say during the whole reading affect the student's motivation. Therefore, it is important for teachers to support students in their learning and use the right strategies (Mata et al., 2012).

According to this scientific experiment, 541 students participated. The author notes that students' interest in mathematics has changed as they move from primary to middle school. 8th graders have less interest in the subject than 7th graders. This is influenced by the internal situation of the classroom, the size of the classroom and the relationship between teacher and student. However, this study was conducted on a very small scale, so it is not necessary to substantiate this information (Deieso & Fraser, 2019). The methods used by the teacher in the classroom play an important role in the formation of attitudes to mathematics, and the teacher, focusing not only on the academic knowledge of students, but also on their personal development and abilities, helps the student to overcome difficulties together (Akinsola & Olowojaiye, 2008). According to this study, 337 students aged 10 to 15 years, if they believed that mathematics was not needed in the future, they would not be able to successfully apply the mathematical knowledge they learned in school when it comes to problems that require analytical skills in everyday life. The teacher can increase the confidence of mathematical ability by the fact that each student is at a different level and a good result can be achieved by asking the teacher what the student does not understand. The higher the student's self-esteem, the higher the link between their efforts and achievement. Based on this research, many students are more concerned about their grades in mathematics, but this does not affect their attitude (Marchis, 2011). Negative attitudes towards mathematics affect a student's self-confidence. If the attitude to mathematics is positive or negative, it can be said that it does not change relative to others (Hannula, 2002). This study examined the relationship between student self-confidence and mathematical achievement. The study was based on the results of TIMSS of students from the USA and Japan. In both countries, the higher the confidence of students in the subject, the greater the mathematical success. This means that students are more likely to succeed if they persevere in their homework. Mathematical achievement of students decreased due to interest in the subject. Japanese students have achieved this through repetition in order to succeed in school. This means that the culture of the state has an impact on learning (House, 2006). The gender of the teacher does not significantly affect the attitude to the subject. Students who are able to control their emotions in a timely manner and use all their efforts in the right direction, have a high level of self-confidence, which is adapted to school life and can communicate well with other classmates.

In addition, students who are able to control themselves during school are more likely to succeed in the future in the areas of life they need (Gollwitzer et al., 2011). If a student has a high level of emotional intelligence, it not only contributes to social life, but also leads to academic success. Therefore, the school should contribute not only to the academic development of students, but also to their social and creative growth. According to this scientific work, according to the author, emotionally well-developed students do not move only in one direction, but set the right goals and make every effort to achieve them (Costa & Faria, 2015). This study looked at the link between cognitive, behavioral, and affective activities and mathematical achievement in Malaysia's 1,000 students. According to the author, the strongest influence on mathematical achievement was affective activity. This means that students' interest in the lesson has a great impact on their motivation. However, students who failed to set the right goals showed low academic performance. Therefore, by increasing the interest in the subject, it is possible to change the attitude of students to the subject and achieve mathematical success (Maamin et al., 2021a). Analyzing the research of this author, it turns out that the activity of the student's behavior, motivation and interest in learning leads to academic success. Enthusiastic students try to understand the question posed by the teacher during the lesson and find a solution to it. This happened to students who said they needed to study accordingly. Therefore, teachers should use a variety of methods and techniques in the classroom (Maamin et al., 2021a).

A study of 295,416 students on the mathematical achievement of factors such as interest in learning and the student factor was conducted. The study was conducted in 34 countries. As a result, a student's affective, behavioral, and cognitive abilities can be considered important factors influencing mathematical achievement. There is a strong link between a student's cognitive ability and mathematical achievement. According to this study, it does not mean that we pay much attention to the cognitive state of the student during the study, but it is very important to bring all the components together. Therefore, the school administration and schoolteachers have a great responsibility. This is because the first priority is for the school administration to be able to guide the school staff and for the teachers to unlock the potential of the students (Fung et al., 2018). The survey was conducted on 3,268 students who passed the PISA. The author sought a link between student activity and academic achievement. It turns out that the efforts of students to overcome learning difficulties contribute to academic achievement. Another finding is that if a student feels close to school, they will be able to increase his or her academic performance by accepting the value of learning. Here the proximity to school shows its importance for the student. Add to that the teacher's impact on the student. A teacher can not only motivate academically, but also contribute to social openness. The teacher can create a special creative atmosphere for students at the university, by adding a variety of activities and projects to the lesson. It is true that the behavioral and emotional development of a student increases the motivation to learn (Lee, 2014).

Table 1. Study respondents

Gender	N	Percentage (%)
Female	35	61
Male	23	39
Total	58	100

Table 2. Categories of participating schools

By category		Percentage (%)
By type	General education school (36)	62
	Lyceum (22)	38
By gender	Girl	61
	Boy	39

Table 3. Shapiro-Wilk for student's attitude, parental support, peer influence, and teacher support

	Teacher support	Peer influence	Parental support	Self-esteem
Shapiro-Wilk W	0.868	0.907	0.905	0.963
Shapiro-Wilk p	< .001	< .001	< .001	0.074

METHODS

Our study used correlation analysis. First, two districts in Kazakhstan were chosen, Almaty district and Shymkent city are included in this study. 58 students from general education school (62%) and lyceum (38%). The profile of the study respondents is shown in **Table 1**. The number of female respondents was 35 (61%), while the number of male respondents was 23 (39%). Categories of participating schools are shown in **Table 2**.

Instruments

The instruments used for this study were scores in the 3rd quarter and a student questionnaire. The student questionnaire was an instrument designed to collect demographic information, students' perceptions of classroom teaching of mathematics and of teacher, peer and parental support, and attitudinal factors. Most items had to be judged on a five-point Likert scale (1 = "strongly disagree" to 5 = "strongly agree").

Data Collection

For the data collection, schools were contacted by social network apps. The students were assured of confidentiality and that the data collected in the study would be used for research purposes.

Data Analysis

Shapiro-Wilk test was used to ensure that all measurements were normal. We used one-way ANOVA for normally distributed samples and non-parametric ANOVA, i.e., Kruskal-Wallis test for non-normally distributed samples. The independent t test was used for gender groups.

Correlation analysis was used to determine the relationship between students' student's attitude, parental support, peer influence, and teacher support, as well as their algebra and geometry grades.

RESULTS

First of all, we carried out a check for each category for normal distribution. Shapiro-Wilk demonstrated that the scores were normally distributed for students' attitude (W[58] = 0.960, p = 0.074) and not-normally distributed for Teacher_Support, Peer_Influence, and Parental_Support (**Table 3**).

We used a one-way ANOVA because the student's attitude scores were normally distributed.

Table 4. One-Way ANOVA (Welch's) for algebra grade

	F	df1	df2	p
Student's attitude	8.14	2.0	32.6	0.001

Table 5. One-Way ANOVA (Welch's) for geometry grade

	F	df1	df2	p
Student's attitude	6.39	2.0	34.7	0.004

Table 6. Kruskal-Wallis algebra grades

	χ^2	df	p
Teacher_Support	11.150	2.0	0.004
Peer_Influence	1.630	2.0	0.443
Parental_Support	2.820	2.0	0.244

Table 7. Kruskal-Wallis geometry grades

	χ^2	df	p
Teacher_Support	9.410	2.0	0.009
Peer_Influence	0.945	2.0	0.624
Parental_Support	3.178	2.0	0.204

Table 8. Correlation matrix results

		Algebra grade	Self-esteem	Parental support	Peer influence
Student's attitude	Pearson's r	**0.424***	-		
	p-value	<.001	-		
Parental support	Pearson's r	0.175	**0.294***	-	
	p-value	0.190	0.025	-	
Peer influence	Pearson's r	0.110	**0.313***	0.208	-
	p-value	0.412	0.017	0.116	-
Teacher support	Pearson's r	**0.397****	**0.416****	0.165	0.217
	p-value	0.002	0.001	0.216	0.102

Note. *<.050; **<.010; & ***<.001

One-way ANOVA results show (**Table 4**) that there was a statistically significant difference in student's attitude scores between algebra grades (F[2, 32.6] = 8.14, p = 0.001) and between geometry grades (F[2, 34.7] = 6.39, p = 0.004) (**Table 5**). In other words, the student's attitude has an effect on his grades in algebra and geometry.

Kruskal-Wallis test showed algebra/geometry scores; the only significant group difference in algebra and geometry grades, as shown in **Table 6** and **Table 7**, is for teacher support ($p_{algebra}$ = 0.009, $p_{geometry}$ = 0.004).

Correlation matrix for the relationships between student's attitude, parental support, peer influence, teacher support and algebra grade are shown in **Table 8**.

There are significant correlation and positive correlation (r = 0.424, p < .001) between students' algebra grades and student's attitude and positive correlation (r = 0.397, p < .001) between algebra grades and teacher support (**Table 8**).

There are significant correlation and positive correlation (r = 0.375, p = 0.004) between students' geometry grades and student's attitude and positive correlation (r = 0.429, p < .001) between students' geometry grades and teacher support (**Table 9**).

According to **Table 10**, independent samples t-test for students' attitude (p = 0.217), there is no significant effect of gender and Mann-Whitney U used for teacher support (p = 0.634), peer influence (p = 0.409), and parental support (p = 0.320) scores of gender (**Table 11**). The results show that there is no significant effect on teacher support, peer influence, parental support of gender groups.

Table 9. Correlation matrix for the relationships between student's attitude, parental support, peer influence, teacher support and geometry grade

		Geometry grade	Self-esteem	Parental support	Peer influence
Self-esteem	Pearson's r	**0.375****	-		
	p-value	0.004	-		
Parental support	Pearson's r	0.115	**0.294***	-	
	p-value	0.389	0.025	-	
Peer influence	Pearson's r	0.090	**0.313***	0.208	-
	p-value	0.500	0.017	0.116	-
Teacher support	Pearson's r	**0.429*****	**0.416****	0.165	0.217
	p-value	< .001	0.001	0.216	0.102

Note. * < .05, ** < .01, *** <.001

Table 10. Independent samples t-test for gender

		Statistics	df	p
Student's attitude	Student's t	1.250	56.0	0.217

Table 11. Results of Mann-Whitney U Test for gender groups

		Statistics	p
Teacher_Support	Mann-Whitney U	373	0.634
Peer_Influence	Mann-Whitney U	351	0.409
Parental_Support	Mann-Whitney U	341	0.320

Table 12. Independent samples t-test for school type

		Statistics	df	p
Algebra grade	Student's t	1.083	56.0	0.284
Geometry grade	Student's t	0.884	56.0	0.381

In this research we surveyed students who study in two types of schools. general education school (36) and lyceum (22). The independent t-test results show there is no significant relationship between algebra grades, geometry grades and school types (**Table 12**). According to the school type for algebra scores there are moderate differences between general education school and lyceum (M_{GS} = 4.22, M_{LYC} = 4.00), and there are moderate differences between general education school and lyceum for geometry scores (M_{GS} = 4.14, M_{LYC} = 3.95).

DISCUSSION

The research showed that there is a significant and positive correlation between students' mathematical achievement and student's attitude (Deveci & Karademir, 2019). This study explains how students' attitudes toward mathematics learning play a significant role in their mathematical achievement. Increasing this parameter can help students perform better in mathematics (Fung et al., 2018). Students' motivation is greatly influenced by their interest in the lesson. Students who did not set appropriate goals, on the other hand, performed poorly academically. As a result, by increasing interest in the subject, it is possible to change students' attitudes toward the subject and achieve mathematical success (Maamin et al., 2021b).

We found that the teacher has a significant effect on the student's mathematical achievement. The meaning of this word shows the influence of the teacher on the motivational mood of the students, in addition to creating a comfortable learning process and increasing their mathematical achievement even more (Tambunan, 2018).

The current study's findings indicate there was no significant difference in attitudes between genders toward mathematics (Anokye-Poku & Ampadu, 2020). Overall, it was concluded that gender may not be a good predictor of attitudes toward mathematics.

According to research works, there is no significant main effect on achievement scores of school types (Recber et al., 2017). According to the school type for algebra and geometry scores there are moderate differences between general education school and lyceum.

This study was conducted with secondary school students in Almaty region and Shymkent city. The process of translation and expert validation was performed to ensure the suitability of the study in the Kazakhstan context. Assumptions of correlation analysis were also performed. The results of the study show that there was a significant relationship between the teacher, student's attitude to the mathematical achievement of secondary school students. Specifically, positive relationships between teacher factors and student self-confidence attitude with mathematical achievement, moderate relationships between class learning environment and class assessment with mathematical achievement were found

CONCLUSION

These results are very important for the field of mathematics education at the high school level. This study explains that teacher factors and student attitude confidence in mathematics learning are key factors in students' mathematical achievement. Teacher factors are represented by teaching and learning strategies. Teacher factors that influence mathematics achievement are pedagogical content knowledge, competency, teaching strategies and attitude

Recommendation

My recommendation for future research is to conduct the study on a larger scale, that is, to increase the number of students participating in the study and to include factors such as the student's home climate and the emotional and social climate of the school setting. In addition, it is necessary to consider the impact of the teaching plan in the educational system on the student's academic progress.

Limitation of the Study

One limitation of the current study is the number of students studying in general public schools (n = 36) and lyceums (n = 22) is not equal. The number of students at one institution may indicate its relative superiority.

A second limitation of the study is general public students are selected from those who study in higher classes (10/11th grades), and lyceum students are only one class (8th grade). The age difference between students has an impact not only on the level of influence, but also on the comprehensive approach to research.

REFERENCES

Adams, A. (1996). *Even basic needs of young are not met*. https://www.tes.com/news/even-basic-needs-young-are-not-met

Afzal, H., Ali, I., Aslam Khan, M., & Hamid, K. (2010). A study of university students' motivation and its relationship with their academic performance. *SSRN*. https://doi.org/10.2139/ssrn.2899435

Akhmetov, A. (2021). *The influence of school climate on Kazakhstani students' academic achievements in the program for international student assessment (PISA)* [Master's thesis, Nazarbayev University].

Akinsola, M. K., & Olowojaiye, F. B. (2008). Teacher instructional methods and student attitudes towards mathematics. *International Electronic Journal of Mathematics Education, 3*(1), 60-73. https://doi.org/10.29333/iejme/218

Allen, N., Grigsby, B., & Peters, M. L. (2015). Does leadership matter? Examining the relationship among transformational leadership, school climate, and student achievement. *International Journal of Educational Leadership Preparation, 10*(2), 1-22.

Anokye-Poku, D., & Ampadu, E. (2020). Gender differences in attitudes and achievement in mathematics among Ghanaian JHS Students. *International Journal of Education, 12*(3), 84-95. https://doi.org/10.5296/ije.v12i3.17136

Azina, I. N., & Halimah, A. (2012). Student factors and mathematics achievement: Evidence from TIMSS 2007. *EURASIA Journal of Mathematics, Science and Technology Education*, *8*(4), 249-255. https://doi.org/10.12973/eurasia.2012.843a

Bhardwaj, A. (2016). Importance of education in human life: A holistic approach. *International Journal of Science and Consciousness*, *2*(2), 23-28.

Caprara, G. V., Barbaranelli, C., Pastorelli, C., Bandura, A., & Zimbardo, P. G. (2000). Prosocial foundations of children's academic achievement. *Psychological Science*, *11*(4), 302-306. https://doi.org/10.1111/1467-9280.00260

Costa, A., & Faria, L. (2015). The impact of emotional intelligence on academic achievement: A longitudinal study in Portuguese secondary school. *Learning and Individual Differences*, *37*, 38-47. https://doi.org/10.1016/j.lindif.2014.11.011

Deieso, D., & Fraser, B. J. (2019). Learning environment, attitudes and anxiety across the transition from primary to secondary school mathematics. *Learning Environments Research*, *22*(1), 133-152. https://doi.org/10.1007/s10984-018-9261-5

Demir, I., Kilic, S., & Depren, O. (2009). Factors affecting Turkish students' achievement in mathematics. *US-China Education Review*, *6*(6), 47-53.

Deveci, O., & Karademir, C. A. (2019). Investigation of the 5th grade students' engagements in mathematics course towards student opinions. *European Journal of Educational Research*, *8*(1), 337-348. https://doi.org/10.12973/eu-jer.8.1.337

Farooq, M. S., Chaudhry, A. H., Shafiq, M., & Berhanu, G. (2011). Factors affecting students' quality of academic performance: A case of secondary school level. *Journal of Quality and Technology Management*, *7*(2), 1-14.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. SAGE.

Frase, L. E., & Sorenson, L. (1992). Teacher motivation and satisfaction: Impact on participatory management. *Nassp Bulletin*, *76*(540), 37-43. https://doi.org/10.1177/019263659207654007

Fung, F., Tan, C. Y., & Chen, G. (2018). Student engagement and mathematics achievement: Unraveling main and interactive effects. *Psychology in the Schools*, *55*(7), 815-831. https://doi.org/10.1002/pits.22139

Georgiou, S. N., Christou, C., Stavrinides, P., & Panaoura, G. (2002). Teacher attributions of student failure and teacher behavior toward the failing student. *Psychology in the Schools*, *39*(5), 583-595. https://doi.org/10.1002/pits.10049

Gollwitzer, A., Oettingen, G., Kirby, T. A., Duckworth, A. L., & Mayer, D. (2011). Mental contrasting facilitates academic performance in school children. *Motivation and Emotion*, *35*(4), 403-412. https://doi.org/10.1007/s11031-011-9222-0

Haider, S. Z., & Hussain, A. (2014). Relationship between teacher factors and student achievement: A correlational study of secondary schools. *US-China Education Review A*, *4*(7), 465-480.

Hampden-Thompson, G., Guzman, L., & Lippman, L. (2013). A cross-national analysis of parental involvement and student literacy. *International Journal of Comparative Sociology*, *54*(3), 246-266. https://doi.org/10.1177/0020715213501183

Hannula, M. S. (2002). Attitude towards mathematics: Emotions, expectations and values. *Educational Studies in Mathematics*, *49*(1), 25-46. https://doi.org/10.1023/A:1016048823497

Haynes, N. M., Emmons, C., & Ben-Avie, M. (1997). School climate as a factor in student adjustment and achievement. *Journal of Educational and Psychological Consultation*, *8*(3), 321-329. https://doi.org/10.1207/s1532768xjepc0803_4

House, J. D. (2006). Mathematics beliefs and achievement of elementary school students in Japan and the United States: Results from the third international mathematics and science study. *The Journal of Genetic Psychology*, *167*(1), 31-45. https://doi.org/10.3200/GNTP.167.1.31-45

Huang, F., Huang, Z., Li, Z., & Zhang, M. (2021). Relationship between parental involvement and mathematics achievement of Chinese early adolescents: Multiple mediating roles of mental health and mathematics self-efficacy. *International Journal of Environmental Research and Public Health, 18*(18), 9565. https://doi.org/10.3390/ijerph18189565

Huebner, E. S., & Gilman, R. (2006). Students who like and dislike school. *Applied Research in Quality of Life, 1*(2), 139-150. https://doi.org/10.1007/s11482-006-9001-3

Kimani, G. N., Kara, A. M., & Njagi, L. W. (2013). Teacher factors influencing students' academic achievement in secondary schools in Nyandarua County, Kenya. *International Journal of Education and Research, 1*(3), 1-14.

Kyriakides, L., Creemers, B. P., & Antoniou, P. (2009). Teacher behavior and student outcomes: Suggestions for research on teacher training and professional development. *Teaching and Teacher Education, 25*(1), 12-23. https://doi.org/10.1016/j.tate.2008.06.001

Lee, J. S. (2014). The relationship between student engagement and academic performance: Is it a myth or reality? *The Journal of Educational Research, 107*(3), 177-185. https://doi.org/10.1080/00220671.2013.807491

Leppel, K., Williams, M. L., & Waldauer, C. (2001). The impact of parental occupation and socioeconomic status on choice of college major. *Journal of Family and Economic Issues, 22*(4), 373-394. https://doi.org/10.1023/A:1012716828901

Maamin, M., Maat, S. M., & Iksan, Z. H. (2021a). Analysis of the factors that influence mathematics achievement in the ASEAN countries. *Cypriot Journal of Educational Sciences, 16*(1), 371-388. https://doi.org/10.18844/cjes.v16i1.5535

Maamin, M., Maat, S. M., & Iksan, Z. H. (2021b). The influence of student engagement on mathematical achievement among secondary school students. *Mathematics, 10*(1), 41. https://doi.org/10.3390/math10010041

MacNeil, A. J., Prater, D. L., & Busch, S. (2009). The effects of school culture and climate on student achievement. *International Journal of leadership in Education, 12*(1), 73-84. https://doi.org/10.1080/13603120701576241

Magelinskaitė-Legkauskienė, Š., Legkauskas, V., & Kepalaitė, A. (2016). Relative importance of social factors linked to academic achievement in the 1st grade. *Social Welfare: Interdisciplinary Approach, 6*, 30-41. https://doi.org/10.21277/sw.v2i6.265

Marchis, I. (2011). Factors that influence secondary school students' attitude to mathematics. *Procedia-Social and Behavioral Sciences, 29*, 786-793. https://doi.org/10.1016/j.sbspro.2011.11.306

Mata, M. D. L., Monteiro, V., & Peixoto, F. (2012). Attitudes towards mathematics: Effects of individual, motivational, and social support factors. *Child Development Research, 2012*, 876028. https://doi.org/10.1155/2012/876028

McLoyd, V. C. (1989). Socialization and development in a changing economy: The effects of paternal job and income loss on children. *American Psychologist, 44*(2), 293. https://doi.org/10.1037/0003-066X.44.2.293

Mohd, N., Mahmood, T. F. P. T., & Ismail, M. N. (2011). Factors that influence students in mathematics achievement. *International Journal of Academic Research, 3*(3), 49-54.

Oginni, O. I. (2018). Home background and students achievement in mathematics. *Journal of Sociology and Anthropology, 2*(1), 14-20.

Opdenakker, M. C., Van Damme, J., De Fraine, D. F., Van Landeghem, G., & Onghena, P. (2002). The effect of schools and classes on mathematics achievement. *School Effectiveness and School Improvement, 13*(4), 399-427. https://doi.org/10.1076/sesi.13.4.399.10283

Peterson, K. D., & Deal, T. E. (1998). How leaders influence the culture of schools. *Educational Leadership, 56*, 28-31.

Recber, S., Isiksal, M., & Koc, Y. (2017). Investigating self-efficacy, anxiety, attitudes and mathematics achievement regarding gender and school type. *Anales de Psicología/Annals of Psychology, 34*(1), 41-51. https://doi.org/10.6018/analesps.34.1.229571

Rouse, C. E., & Barrow, L. (2006). US elementary and secondary schools: Equalizing opportunity or replicating the status quo? *The Future of Children*, *16*(2), 99-123. https://doi.org/10.1353/foc.2006.0018

Sanders, W. L., Wright, S. P., & Horn, S. P. (1997). Teacher and classroom context effects on student achievement: Implications for teacher evaluation. *Journal of Personnel Evaluation in Education*, *11*(1), 57-67. https://doi.org/10.1023/A:1007999204543

Shin, J., Lee, H., & Kim, Y. (2009). Student and school factors affecting mathematics achievement: International comparisons between Korea, Japan and the USA. *School Psychology International*, *30*(5), 520-537. https://doi.org/10.1177/0143034309107070

Shindler, J., Jones, A., Williams, A. D., Taylor, C., & Cardenas, H. (2016). The school climate-student achievement connection: If we want achievement gains, we need to begin by improving the climate. *Journal of School Administration Research and Development*, *1*(1), 9-16. https://doi.org/10.32674/jsard.v1i1.1905

Shouppe, G., & Pate, J. L. (2010). Teachers' perceptions of school climate, principal leadership style and teacher behaviors on student academic achievement. *National Teacher Education Journal*, *3*(2).

Solomon, D., Rosenberg, L., & Bezdek, W. E. (1964). Teacher behavior and student learning. *Journal of Educational Psychology*, *55*(1), 23. https://doi.org/10.1037/h0040516

Tahar, N. F., Ismail, Z., Zamani, N. D., & Adnan, N. (2010). Students' attitude toward mathematics: The use of factor analysis in determining the criteria. *Procedia-Social and Behavioral Sciences*, *8*, 476-481. https://doi.org/10.1016/j.sbspro.2010.12.065

Tambunan, H. (2018). The dominant factor of teacher's role as a motivator of students' interest and motivation in mathematics achievement. *International Education Studies*, *11*(4), 144-151. https://doi.org/10.5539/ies.v11n4p144

Tauer, J. M., & Harackiewicz, J. M. (2004). The effects of cooperation and competition on intrinsic motivation and performance. *Journal of Personality and Social Psychology*, *86*(6), 849. https://doi.org/10.1037/0022-3514.86.6.849

Webster-Stratton, C., & Reid, M. J. (2004). Strengthening social and emotional competence in young children–The foundation for early school readiness and success: Incredible years classroom social skills and problem-solving curriculum. *Infants & Young Children*, *17*(2), 96-113. https://doi.org/10.1097/00001163-200404000-00002

Weiss, C. C., & García, E. (2015). Student engagement and academic performance in Mexico: Evidence and puzzles from PISA. *Comparative Education Review*, *59*(2), 305-331. https://doi.org/10.1086/680170

Please cite: Kaymak, S., Sautkali, A. (2022). The Factors that Affect Mathematical Achievement Among High School Students. *Journal of Research in Didactical Sciences*, *1*(1), 12733. https://dio.org/10.51853/jorids/12733

Received: 09 November 2022 ● Accepted: 21 December 2022