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Effects of Computer Animations on Students' Geometrical Mathematics Misconceptions in Secondary Schools, Kitui County, Kenya

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Abstract

Children come across mathematics before they start schooling. From infancy to secondary, they develop mathematical concept formation skills and hold misconceptions. Learning mathematics concepts is spiral in nature, with one level affecting later learning. Poor performance in mathematics is traceable back to Mathematics Misconceptions held by students at an early age. Animations has been used in Symmetry and Matrices with a remarkable reduction of students' misconceptions. Their use in photoelectric effect in physics signifipppppcantly reduced students' misconceptions. This study inquired into the effects of computer animations on geometrical misconceptions. The constructivist theory of learning guided the study where prior knowledge in geometry was used to build geometrical concepts from day-to-day life experiences. The study employed Solomon-Four Group Design with experimental and control categories having two groups each. The four groups for the study were purposively chosen. 112 boys and 95 girls participated in the research. MAT (Mathematics Achievement Test) adopted from past KCSE (Kenya Certificate of Secondary Education) questions were used to find the misconceptions held by students. The instrument was pilot-tested and resulted in a reliability coefficient of 0.8826 using the KR-20 formula. Pre-testing was done to the control and an experimental group before intervention, and all the four groups sat for a Post-test. ANOVA and t-test were applied in the testing of the hypothesis at a 0.05 level of confidence. With the use of Animation, a reduction of students' mathematical misconceptions was observed. The performance of boys and girls after exposure to animations were noted to be significantly the same. The findings may help stakeholders in Mathematics Education.

Keywords: Concepts, Misconceptions, Students, Computer, Animation

A. Introduction

Mathematics is a subject dreaded by many people from all walks of life worldwide. Some members of communities are unaware, that mathematics is more than what is taught at school while some teachers have misconceptions that mathematics is easy and it is common to get non-mathematics teachers advising students that for every formula, they write in an examination they get a mark. The students see mathematics as a collection of many formulae to be used in working without necessarily knowing how the formulae were derived. Verniers and Vala (2018) reported that the subject is see as difficult to student and hence stereotyped as meant for boys and not for girls. Gender difference in mathematics ability remains a concern worldwide with women being under-represented at the higher level of mathematics (Ajai & Imoko, 2015).

Every student, especially in secondary school desires to do well in mathematics. However, despite the Governments' effort worldwide to improve mathematics performance, the students continue to perform dismally. The performance is poor in the subject due to lack of inadequate teaching resources, misconceptions, lack of ICT integration in classrooms, and gender stereotypes among others. Geometry has been a challenging topic in mathematics to teach and learn. Animations have been used in Physic concepts on Force and Motion with a significant reduction of student's misconceptions and minimal gender differences observed. The research sought a teaching technique that would reduce misconceptions held by the students. Computer Animations were used during students' instruction in Geometry. Traditional teaching methods rarely focus on students' prior knowledge, real-life situations, and the causal effects of their non-performing.

The study purposed to investigate, computer animations' effects on students' geometrical mathematics misconceptions by gender in secondary schools of Kenya's Kitui County. The study's objective was to establish whether there was gender difference in mathematics misconceptions held by Students in geometry when they were exposed to Computer Animations during mathematics instruction.

B. Literature Review

1. Gender Differences in Students' Mathematics misconception

A concept is the basic unit of all types of learning used to specify attributes that are useful in understanding the great variability among a variety of objects (Akhilesh, 2014). A misconception on the other hand, as noted by Hestenes, Wells, and Swackhamer (1992) is an alternate conception that differs from that of experts in the field. Students come to class with their ideas about certain mathematical concepts and many times, their ideas differ from the right concept. The differences can be resolved through remedial teaching to correct the wrong concept. Remedial measures are of no consequence on students unless, they acknowledge that past experiences are in conflicts with the new knowledge (Maloney, 1994). It is important to design mathematical instructions that address students' misconceptions to improve their ability to apply mathematics concepts in real situations.

Gender refers to the cultural roles and responsibilities assigned to men and women in families, and societies. Thekla, Gustafsson, Lindqvist, Renstrom, Ryan, and Morton (2020) see gender as roles associated with women and men in a specific culture. Traditionally as noted by Verniers and Vala (2018) women have been discriminated against and disadvantaged globally. This has however resulted in educational gaps between boys and girls. They also observed that there are gender gaps in education resulting from socio-economic factors, accessibility to learning resources, and cultural stereotypes about the girls' education.

Ritu (2013) argues that misconceptions emanate from faulty thinking due to the previously wrongly constructed concepts. Thus, resulting in the formation of wrong schemata of knowledge. However, Ramazan and Osman (2012) view misconceptions as mistaken ideas or results of misunderstandings of something. Allen (2007), argues that problems leading to very serious learning difficulties in mathematics are misconceptions that students hold from previous inadequate teaching. On the other hand, Sarwadi and Masitah (2014) argues that students hold misconceptions if teacher-centered methods are used frequently; the teacher fails to cover the curriculum in-depth; he fails to take into account the students' prior knowledge and experiences; he uses inappropriate teaching methods, and he holds misconception due poor mastery of content. Students also hold Misconceptions, if they fail to connect the subjects and concepts, and if they fail to relate the subjects to their real-life experiences.

Erylmaz (2002) observed gender differences in misconceptions about Forces and Motion concepts in Physics. While Omwirhiren and Ubanwa (2016) found that in organic chemistry, both boys and girls held misconceptions. The study by Driver (1989) also found out that girls held more misconceptions in chemistry than boys. On the contrary research by Ritu (2013) on geometrical misconceptions revealed that the boys made slightly more misconceptions than girls, although the impact had no significant difference by gender. Researchers have not established a single direction of students' misconception by gender.

Students come to school with lots of misconceptions emanating from prior knowledge. It is the responsibility of mathematics' teachers to find out the learners' misconceptions and address the conceptual challenge if meaningful learning is to take place. Hung and Khine (2006) noted that misconceptions of phenomenon type are corrected using Computer animations due to their unique nature of visualizing the concept from various angles. They supported Anderson and Skwarecki (1986) who see a computer as a tool used to clarify mathematics concepts through graphics' designs and visual. There is no common instructional strategy in mathematics that addresses all the students' misconceptions. The instructions vary according to the nature of the concept. Misconceptions may result from beliefs, metaphors, and instructional environment among others (Maguire, 2012), this implies that the identification and remediation of misconceptions are largely localized to a class or school and its surroundings.

In Kenyan secondary school like anywhere else in the world, students come to school with a wealth of real-life experiences and prior knowledge of various geometrical concepts. They also hold misconceptions in geometrical concepts that need teachers to address. KNEC (2013) revealed from the past KCSE mathematics examinations analyses that, students' performance has been poor in Geometry due to careless mistakes, errors, and misconceptions. KNEC advises the teachers to give the students more questions during the teaching of mathematical concepts to give learners adequate practice, perfect their skills, and re-conceptualize the mathematics' concepts. In this study, the misconceptions held in Geometry, were sought and addressed through the use of Computer Animations during the teaching instructions.

2. *The Study's Frameworks*

The research is firmly grounded on Theoretical and Conceptual frameworks which provides the roadmap of the study. The frameworks' foundations make meaningful research findings which are acceptable to the rapidly growing body of knowledge, ensuring it is generalizable.

Adom and Emad (2018) see the theoretical framework as a 'blueprint' for guiding research. The framework is anchored on theories guiding the research which should resonate well with the research procedure. The Constructivists Theory by Piaget guided this study. The theory states that learners construct their knowledge through experience (Piaget, 1970). The learners constructed geometrical concepts from real-life experiences through animations. Learners' prior knowledge affects students' learning in mathematics either positively or negatively during instructions. If the prior knowledge is against the experts' opinion, then, it affects the learners negatively hence leading to misconceptions. According to Bruner (1986), meaningful learning takes place when prior knowledge and experiences create connections with the new information or knowledge.

According to Passey (2020) a conceptual framework is a description of identified factors and criteria that have great influence on a research. It also provides a logical analytical display of variables for easy interpretation of the researched concepts (Grant & Osanloo, 2014). In this study, the framework shows Computer Animations as an independent variable with Conventional teaching as a control variable. The dependent variable for the research is students' misconceptions in geometrical mathematics. The framework displays all variable under research and shows the likely influence on each other.

Intervening variables are important factors for consideration in research since they may influence its outcome. Hypothetically they are variables that cannot be observed and hence, it is not possible to quantify from the outcome how much of the effect is due to the independent or intervening variable individually. Cautious observations are needed to decrease the influence of intervening variables on the dependent variable. The intervening variable should be critically analyzed when planning research and when evaluating the results after the data collection. Some intervening variables are anticipated, while others are revealed during the study. Those that are anticipated are addressed by using specific experimental design techniques. Those that are revealed during the study, help in the interpretation of the research findings. The teachers', schools', and students' factors are some of the intervening variables identified in this research. The teachers' academic qualifications, and professional experiences were anticipated and controlled ensuring only graduate teachers who had taught Form Four class for more than two years participated in the research.

It is important for teachers to be conversant with operations and applications of teaching aids before using them in the actual teaching. The teachers using the Computer Animations had five days training on usage of Animation in line with the teaching guide. The teaching of the Geometry topic took three weeks as stipulated by KIE (2002). The research focused on Co-educational Secondary Schools which are the majority. Geometry is a Mathematical topic taught to Form Four students as “Loci” and as such the research was confined to them only, with an assumption that they are relatively the same age. A representation of how variables relate in the conceptual framework is given in Figure1

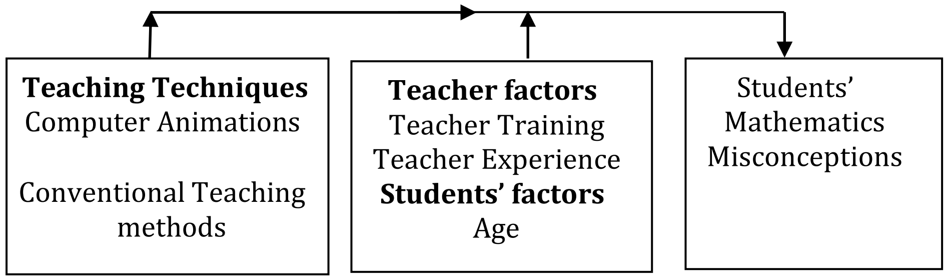


Figure 1. Conceptual Framework relating variables of the Study.

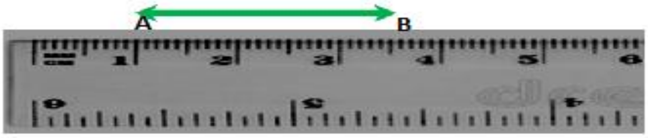
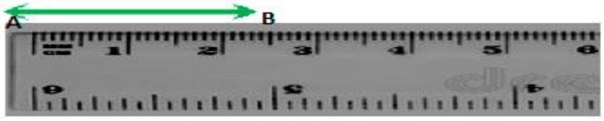
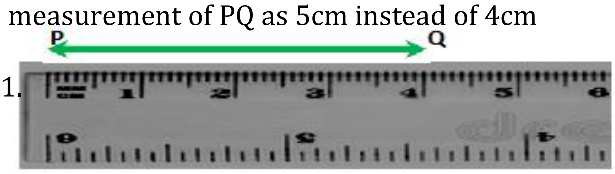
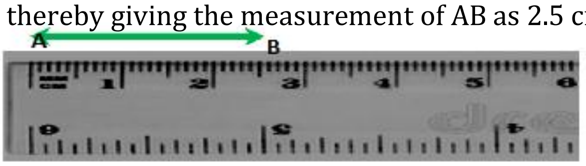
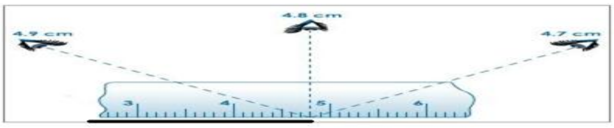
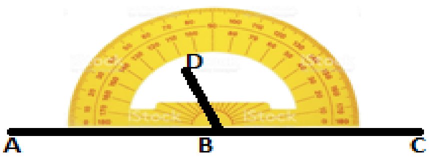
3. *Analysis of Students’ Misconceptions in Mathematics*

Misconception analysis involves discovering and comprehending the students’ misunderstandings in given concepts and exposing them. For instance the assumption that the earth is flat ruled the world for some time and the interpretation of the concept of the earth and the universe depended entirely on the assumption (Russel, O’Dwyer, & Miranda, 2009). If a modern science teacher were to teach about the universe to students of 300 BC, the teaching would be incomprehensible to them. They would resist these teachings if the teacher first did not demystify for them modern information about the earth and the universe (Cohen, 1972).

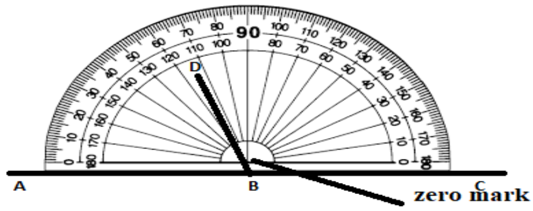
Murdoch (2018) cited in Soeharto, Csapó, Sarimanah, Dewi, and Sabri (2019), come up with five classes of misconceptions which he categorized as, preconceived perceptions; briefs without scientific backing; conceptual misunderstandings, vocabulary deficiency, and incomprehensible factual-reality. Some of the methods used to detect these misconceptions include interviewing the students; giving students open-ended test; use of simple, two-tier, three-tier, or even four-tier multiple choice tests (Soeharto, *et al.*,2019). Misconceptions’ analyses are useful for teaching and learning, they help students to understand where they are likely to go wrong and avoid it. Geometry is a difficulty subject to students and as such, Cheng-Fei (2012) argues that, it is important to establish the commonly made mistakes in geometry and find their cause in order to provide remedy. This is supported by Dowker (2005) who emphasizes the importance of early identification of learners’ challenges and instant remediation to prevent misconceptions in problem solving. Students make remarkable progress and self-regulate their learning if the learning challenges and misconceptions are addressed early (Croark, Mehaffie, McCall & Greenberg, 2007).

Formulae methods are used to solve problems that require a lot of arithmetic operations and accurately recall of formulae (Mona, Malik & Meenu, 2013), this leaves students with numerical values that lack clear meaning and conceptual understanding, thus leading to increased incidences of misconceptions. Daymude (2010) noted that it is often difficult to understand the reasons that lead to a student missing a test item in the examination, especially the items that student never attempted. This leaves the examining teacher with many questions such as: did the student accidentally skip the item? Did the student mean to come back to that item and forget to do so? Or was the item too difficult for the student? Was the student time banned? These questions can only be answered if the teachers interview students (Soeharto, et al., 2019). Cirillo and Hummer (2019) observed that most commonly encountered students' misconceptions were notions regarding measurements using a ruler directly and protractor without any regard to Parallax error. Table 1 shows mathematical misconceptions in geometry.

Table 1. Learners' Mathematics Misconceptions in Geometry

Misconceived concept	**Sub-concept**	**Misconceptions**
Measurements	Length Using a ruler	A Student begins measuring at the number 1 instead of a zero and does not compensate thereby giving measurement as 3.8 cm instead of 2.8 cm.  The Student starts their measurements from the tail the end of the ruler instead of at zero thereby giving the measurement of line AB as 2.3 cm  When measuring with a ruler, the student counts the lines instead of the intervals thereby giving the measurement of PQ as 5cm instead of 4cm 1.  The correct way of measurement is using divider, thereby giving the measurement of AB as 2.5 cm 
	Parallax error	In a geometrical set, a divider is a tool that is rarely used by students to transfer the measurement to the ruler. It is the tool that does not get lost in a mathematical set. The result of using the ruler to directly measure the length is parallax error.  The correct position to use the ruler to measure length is to position the eye perpendicularly at the mark on the scale to avoid parallax error.
Measurements	Angles-Using protractor	Some of the protractors used are not compact; if the lines do not reach the calibrated scale, then the students are likely to approximate the angle thereby making errors that may lead to misconceptions. 

The students are expected to produce the line BD to reach the scale for accurate measurement
Some students fail to start from the zero mark in the protractor. This may lead to errors and if consistently done may be termed as a misconception.



Source: Riccomini, (2014), 322-325 Cirillo and Hummer (2019) 412,

C. Methodology

1. Research Design

The study used Solomon-Four Control Group Design with two treatment groups (Tingen, 2009), which is an experimental research design suitable for intact groups. This design allows researchers to use classes as constituted in education institutions. The schools' administrators do not allow disruption of classes (Kasee,2016). This design is useful in that it accounts for how pre-testing before exposure to an intervention may later influence post-test results after the interventions are done. The research design show that when subjects are exposed to an intervention, then differences in pre-test in comparison to post-test scores are as a result of the intervention (Hwang & Sim, 2019).

Group	Pre-test	Intervention	Post-test
E1	O_1	X	O_2
C_1(38)C1	O_3	—	O_4
E_2 (46)E2	—	X	O_5
C2	—	—	O_6

Figure 2: Research Design layout

C1 and C2 denote control groups while E1 and E2 represent experimental groups. O1and O3 are Pre-test while O2, O4, O5, and O6 are Post-test. In Figure2, X represents presence of intervention while (-) presents absence intervention and pre-test.

2. Research Location and Research Subjects

The research was done in Kitui County's secondary school targeting the entire students' population. The county has 268 Co-educational secondary schools out of 380 secondary schools (KCEO, 2017). The study did not cover the entire target population and hence the need to identify the part of the population that could be reached (Asiamah, Mensah & Oteng-Abayie, 2017). The researched geometrical topic is covered in Form Four. Hence, the accessible population was all the 16,532, Form Four students in the county and particularly those in Co-educational secondary school who are the majority (KCEO, 2015; 2017).

3. Sample Size and Sampling Procedures

Purposive random sampling was useful in choosing the four schools that took part in the study from the sixteen Sub-Counties in Kitui. This ensured that the chosen schools were sparsely distributed to avoid interaction; had mathematics graduate teachers; a computer laboratory with at least ten computers; and evenly distributed by gender. There were 95 girls and 112 boys who participated in the research.

4. Instruments

MAT was used to find geometrical misconceptions held by students. It had a total of 30 items where a student who held all misconceptions scored 50 marks while one who held no misconceptions scored zero (0) mark. Teachers administered the instrument to two groups as a pre-test and the same instrument was given to all the groups as a post-test. The test was done for two hours under strict observation of examination regulations.

5. Technique of Data Analysis

Data analysis involves the process of sorting the data, coding, cleaning and processing and results interpretation (Muhammad, 2015). The data collected using the instruments was analyzed using Statistical Package for Social Sciences (SPSS) version 21.0. The independent t-test was used to determine the significance of mean differences in mathematical misconception between the Experimental group E_1 and the control group C_1 on pre-test. T-test is suitable for comparison of characteristics of two groups that are independent (Liang, Fu, and Wang, 2019). The test was used to establish gender disparity in misconceptions held by students. One-way ANOVA was used to establish the significant difference in mathematics misconceptions between the groups' post-test results. ANOVA is appropriate for testing more than two groups (Zhou & Skidmore, 2017). The inferential statistics was used to test the hypotheses at a confidence level of 95% (Foster, 2014), which is the same as coefficient alpha (α) level value equal to 0.05 (Greenland, Senn, Rothman, Carlin, Poole, Goodman, & Altman, 2016).

The hypothesis H_0 of the study tested at a significant confidence level of 95% stated that there was no statistically significant gender disparity in Geometrical misconceptions between students exposed to Computer Animation and those exposed to conventional teaching methods.

D. Research Findings and Discussion

1. Results and Discussions

a. Distribution of the students by gender

Table1, shows the distribution of boys and girls in the sampled school that was fairly well balanced with an exemption of E2 where 63% of the students were boys. Most of the classes were big enough to accommodate the students, with exception of C1 where the students were overclouded. Only C2 had met the Ministry of Education recommendations for secondary schools not exceeding 45 students per class (MoEST, 2005).

Table 2 Distribution of students per group.

	C1	E1	C2	E2	TOTAL
Girls	24	26	26	19	95
Boys	35	25	19	33	112
TOTAL	59	51	45	52	207

b. Pre-test results of mathematics misconception

The groups C1 and E1 sat for MAT and the misconception held by the students counted at the pre-test. Each misconception held by a student awarded one mark and the total misconceptions for each student formed his or her misconception score. Table 3 gives the misconception mean score, the standard deviation, and standard error of C1 and E1; where C1 had slightly more misconceptions than E1.

Table 3. Mean Scores on Misconception in MAT for groups E1 and C1

GROUP	N	Mean	Sd.	SE
C1	59	36.02	10.212	1.330
E1	51	33.55	9.151	1.281

Seltman (2018) recommends that it is important to find out how homogeneous the groups are before exposing the subjects to the treatment in research. Table4 gives the results of the t-test of misconception sores, whose purpose was to test whether C1 and E1 were homogeneous before treatment.

Table 4. t-test for pre-test on misconceptions scores

Variable	Group	N	Mean	Sd.	df	t-computed	t-critical	p-value
MAT	C1	59	36.02	10.212	108	0.188	1.9864	0.270
	E1	51	33.55	9.151				

*Not significant at p>0.05 level
*Critical values (df= 120, t =1.98, p<0.05)
Calculated values (df=108, t = 0.188, p = 0.270)
t- Computed < t – critical

The results show that the differences between misconception mean scores of groups E1 and C1 on the MAT were not statistically significant at the α=0.05 level (t (108) = 0.188 and p > 0.05). The t-test is best suited in comparing two groups. The lack of pre-existing differences between treatments and controls groups implies that the control group yields reliable results of what would have happened to students if Computer Animations were not used, and when these results in comparison with the outcomes for students exposed to Computer Animation, reliable estimates of treatment impacts were obtained. Table 5 shows the misconception scores from MAT held by students by gender and groups C1 & E.

Table 5. Pre-Test Misconception Score by Gender and By Group

Group	Gender	Mean	N	Sd.	SE
C1	Girls	36.75	24	10.605	2.165
	Boys	35.51	35	10.060	1.700
E1	Girls	33.23	26	8.076	1.584
	Boys	33.88	25	10.309	2.062

The misconception scores for both boys and girls were almost the same with girls holding slightly more misconceptions than boys in C1. In E1 the boys made slightly more misconceptions than girls. Joel *et al*., (2015) had observed in their studies that both boys and girls hold significantly the same mean misconceptions in learning sciences and mathematics. The two groups had no statistically significant difference in misconceptions by gender implying that their characteristics were the same and hence fit for study. Table 6 shows the overall pre-test students' misconception score in MAT by gender.

Table 6. Overall Pre-Test Students' Misconception Score by Gender

Gender	N	Mean	Sd.	SE
Girls	50	34.92	9.446	1.336
Boys	60	33.98	9.123	1.305

The overall misconceptions held in MAT by girls and boys in the pre-test of the two groups show that the girls made slightly more misconceptions than boys. This agrees with Asyura, Nur, Salimah, Nor, Aminatul, (2017), who also found that girls held slightly more misconceptions in calculus than boys. The results of t-test from pre-test scores comparing boys and girls are presented in Table 7.

Table 7. Pre-Test Scores' t-Test By Gender

Variable	Group	N	Mean	Sd.	df	t-computed	t-critical	p-value
MAT	Girls	50	34.92	9.446	108	0.528	1.9864	0.599
	Boys	60	33.98	9.123				

* Not significant at p>0.05 level
*Critical values (df=120, t =1.98, p<0.05) Calculated values (df=108, t = 0.528, p = 0.599)

The average scores of misconceptions for boys and girls revealed that there was no statistically significantly different, t (108) = 0.528 and p>0.05. This showed that the groups had the same features.

2. *Effects of Computer Animation on Geometrical Mathematics Misconception by Gender.*

The hypothesis H_0 that tested if Computer Animation had any effect on a geometrical misconception by gender was analyzed. After interventions, all four groups sat for Post-test

MAT. Table 8 shows the mean score of the mathematics misconceptions held by the students by gender per group.

Table 8. Post-Test Misconceptions Mean Score by Gender per group

POST TEST	C1		E1		C2		E2		Total
Gender	F	M	F	M	F	M	F	M	
Mean	32.25	34.06	28.73	27.12	36.27	37.37	27.00	27.15	31.17
N	24	35	26	25	26	19	19	33	207
Std. Deviation	9.892	8.331	8.234	8.511	8.12	6.865	9.171	8.827	9.273

The post-test results on mathematics misconception mean score show that Girls performed better than their Boys counterparts in all the groups except E1 where the Boys outperformed the Girls. All the students held misconceptions in Geometry which agrees with Omwirhiren and Ubanwa (2016) observed that both Boys and Girls held misconceptions in inorganic chemistry. Table 9 shows the overall post-test misconception result for MAT by gender.

Table 9. Overall post-test misconception Result

	GENDER	N	Mean	Sd.	Std. Error Mean
POST-TEST	Girls	95	31.34	9.395	0.964
	Boys	112	31.03	9.208	0.870
	Total	207	31.17	9.273	0.645

The overall misconceptions of the boys were fewer than those of the girls in MAT as shown in Table 9. This agrees with Omwirhiren and Ubanwa (2016) who observed that girls held more misconceptions than their boys in inorganic chemistry. This also agrees with Ahmed, Tariq, and Tahseen (2012) who observed that overall, there are higher proportions of gender misconceptions held by girls than by boys at the secondary level in Pakistan. Table10 gives the independent t-test by gender of post-testing.

Table 10. t-test by gender for post-testing

Variable	Group	N	Mean	Sd.	df	t-computed	t-critical	p-value
MAT	Girls	95	31.34	9.395	205	0.239	1.984	0.811
	Boys	112	31.03	9.208				

A total of 95 girls and 112 boys did the post-test. The misconceptions differences between boys and girls were not significant, t (205) = 0.239, p > 0.05. The boys and girls held relatively the same misconceptions. On the contrary Ahmed *et al.* (2012) observed that 82% of girls and 96% of boys held misconceptions that the solution the mixture of oil and water forms a "chemical solution". This implies that boys held more misconceptions than girls. Table 11 gives the mean score gain of student's misconception scores in MAT by gender.

Table 11. Comparison of Misconception Score Gain Pre-Test and Post-Test Scores

Test	Boys	Girls
Pre-test	34.83	34.92
Post-test	31.17	30.42
Mean gain	3.66	4.50

The boys made slightly fewer misconceptions than girls in the pre-test examinations, however in the post-test they made more misconceptions. The mean gain in post-test over the pre-test for boys is slightly lower than that of girls. The gain is not significant. The misconceptions held by girls and boys in Algebra are not significant as observed by Booth, Koedinger and Siegler, (2007). This assertion agrees with the findings of this research. On the contrary, Erylmaz (2002), observed significant gender differences in the misconceptions on Force and Motion concepts when using computer animations. The boys held fewer misconceptions than the girls. However, the statistical analysis did also indicate that the overall gender differences observed in the misconception scores were not significant.

It is important to remediate misconceptions to create a conducive learning environment for students to do their best in mathematics. It is then necessary to choose an appropriate instructional approach and technique with instructional technologies for they have been found to reduce misconceptions (Özcan, Çetin & Koştur, 2020). In comparison with other research studies, the results findings support earlier studies. The finding of (Erylmaz, 2002) indicated that students have misconceptions in Force and Motion, however both boys' and girls' misconceptions are relatively similar. In this study, the students held misconceptions on Geometry with boys having slightly fewer misconceptions than the girls. The misconceptions were insignificant which agrees with Booth *et al.,* (2007), who found that both boys and girls held misconceptions in algebra but were not statistically significant. On the contrary, Ahmed *et al.* (2012) found boys held slightly more misconceptions than girls about the chemical solution in chemistry but overall, the differences were not significant.

E. Conclusion

In conclusion, this study found out that the computer animation reduces geometrical mathematics misconceptions for both boys and girls. It also found that boys and girls held relatively the same misconceptions scores in Geometry.

Implications of the Study are a) Boys and girls hold relatively similar misconceptions when using Computer animations to teach them Geometry; b) Computer animations reduce mathematics misconceptions in geometry irrespective of gender; and c) The gender difference in mathematics misconceptions held by students is not significant when using computer animations to teach Geometry.

Recommendations are a)Mathematics teachers should learn to develop mathematics animations based on the concepts they teach that are too abstract for the students; b) Mathematics Teachers should integrate animations as an ICT tool in their teaching and learning for it is found to reduce mathematics misconceptions; c) Education stakeholders should invest in computer animations by providing the necessary software and equipment to equip the teachers; d) In-service by MOEST, CEMESTEA, TSC, and KICD should also incorporate Computer animations, simulations in their programs.

Suggested areas of further research are a) The study shows that Computer Animations reduces misconceptions in Geometry. Further research to find out whether the same happens across all mathematics topics in the entire mathematics syllabus; and b) Animating real-life experiences of students to discuss their mathematical misconceptions.

F. References

Adom, D., & Emad, K. H. (2018) And Conceptual Framework: Mandatory Ingredients of a Quality Research. International Journal of Scientific Research, Volume-7 | Issue-1 | January-2018 | Issn No 2277 - 8179

Ahmed, S. A., Tariq, M. K. &Tahseen, M. A. (2012). The Disparity in Misconceptions about the Concept of Solution at Secondary Level Students in Pakistan. Journal of Elementary Education Vol.22, No. 1 pp.65-79

Ajai, J.T. & Imoko, I.I. (2015). Gender differences in mathematics achievement and retention scores: A case of problem-based learning method. International Journal of Research in Education and Science (IJRES), 1(1), 45- 50.

Akhilesh P.T. (2014) "Identification of misconceptions in physics and testing of the effectiveness of certain instructional programs on remediation of the misconceptions among VIII standard students in Kerala" Thesis. Department of Education, University of Calicut, 2014.

Allen, G. D. (2007). Student Thinking: Misconceptions in mathematics Texas A & M University-College Station, TX 77843-3368.

Anderson, J. R., &Skwarecki, E. (1986). The automated tutoring of introductory computer programming. *Communications of the ACM*, 29, 842-849.

Asiamah, N., Mensah, H. K., & Oteng-Abayie, E. (2017). General, Target, and Accessible Population: Demystifying the Concepts for Effective Sampling. The Qualitative Report, 22(6), 1607-1621. Retrieved from http://nsuworks.nova.edu/tqr/vol22/iss6/9

Asyura, A. N., Nur, H. M. A., Salimah, A, Nor H. T, & Aminatul, S. I. (2017). The mathematical misconception in calculus 1: Identification and gender difference. AIP Conference Proceedings 1870, 070001 (2017).

Booth, J.L., Koedinger, K.R., & Siegler, R.S. (2007). The effect of prior conceptual knowledge on procedural performance and learning in algebra. In D.S. McNamara & J.G. Trafton (Eds.), Proceedings of the 29th Annual Cognitive Science Society. Austin, TX: Cognitive Science Society.

Bruner, J. S. 1986. Actual Minds, Possible Worlds. Cambridge, MA: Harvard University Press.

Cheng-Fei, L. (2012). Error Analysis in Mathematics. Technical Report # 1012 University of Oregon, Behavioral Research and Teaching.

Cirillo, M and Hummer, J (2019). EPTIONS in Secondary Geometry Proof. Use these ideas to diagnose and address common conceptual obstacles that inhibit students' success. MATHEMATICS TEACHER | Vol. 112, No. 6 • April 2019 pp 410 - 417

Cohen, D. (1972). "Is the earth flat or hollow?" Science Digest, Nov. 1972, p. 62-66.

Croark, C. J, Mehaffie, K. E, McCall, R. B &Greenberg, M.T., (2007). Evidence-Based Practices and Programs for early childhood. United Kingdom: Sage.

Daymude, K., (2010). Test Error Analysis in Mathematics Education: A Mixed-Method Study. Unpublished Ph.D. Thesis in Mathematics Education of University of ATHENS, GEORGIA

Dowker, A.D (2005). Early identification and intervention for students with mathematics difficulties. University of Oxford, Vol. 38, No 4 July/August 2005, 324 – 332.

Driver, R. (1989). Changing conception in adolescent development and school science. London: Falmer Press

Erylmaz, A. (2002). Effects of Conceptual Assignments and Conceptual Change Discussion on Students' Misconceptions and Achievement Regarding Force and Motion. Journal of Research in Science Teaching, 39(10), 1001-1015.

Grant, C. &Osanloo, A. (2014). Understanding, Selecting, and Integrating a Theoretical Framework in Dissertation Research: Creating the Blueprint for 'House'. Administrative Issues Journal: Connecting Education, Practice and Research, Pp. 12-22 DOI: 10.5929/2014.4.2.9

Greenland, S., Senn, S. J., Rothman, K.J., Carlin, J.B., Poole, C., Goodman, S.N., and Altman, D.G. (2016). Statistical tests, P values, confidence intervals, and power: a guide to misinterpretations. Eur J Epidemiol (2016) 31:337–350 DOI 10.1007/s10654-016-0149-3

Hestenes D. & Wells M. (1992). A Mechanics Baseline Test. The Physics Teacher, 30, 159-162.

Hung, D. &Khine, M.S (2006). Engaged learning with Emerging Technologies. Springer, Dordrecht.

Hwang, E. J and Sim, I. O (2019). Effect of a Comprehensive Health Care Program on Blood Pressure, Blood Glucose, Body Composition, and Depression in Older Adults Living Alone: A Quasi-Experimental Pretest–Posttest Study. International Journal of Environmental Research and Public Health. Pg. 1-10.

Joel, D., Berman, Z., Tavor, I., Wexler, N., Gaber, O., Stein, Y., & Margulies, D. S. (2015). Sex beyond the genitalia: The human brain mosaic. Proceedings of the National Academy of Sciences, 112 (50), 15468–15473.

KCEO, (2015). Kitui County Education Office: -Kitui County TSC-Staff Return for August 2015, KCEO Kitui.

KCEO, (2017). Kitui County Education Office; - Kitui County TSC-Staff Return for March 2017, KCEO Kitui.

KIE, (2002). *Secondary Education Syllabus Vol.2.*Nairobi: KIE.

KNEC, (Kenya National Examination Council) (2013). The KCSE Examination Report, Nairobi: KNEC.

Liang, G., Fu, W. and Wang, K (2019). Analysis of t-test misuses and SPSS operations in medical research papers. Burns & Trauma, Volume 7, 2019, s41038-019-0170-3, https://doi.org/10.1186/s41038-019-0170-3

Maguire, T. J. (2012), "Investigation of the Misconceptions Related to the Concepts of Equivalence and Literal Symbols Held by Underprepared Community College Students". Doctoral Dissertations. 40.

Maloney, David P., (1994). Research on Problem Solving: Physics. In Gabel, Dorothy L. (Ed.), Handbook of Research on Science Teaching and Learning, New York: MacMillan Publishing Company.

MoEST (2005). Education sector report. Nairobi: Ministry of Education, Science, and Technology.

Mona, B., Malik, A and Meenu, D (2013). FORMAL METHODS: BENEFITS, CHALLENGES AND FUTURE DIRECTION. Journal of Global Research in Computer Science. Volume 4, No. 5, pp 21-25

Muhammad, I. (2015) art of Data Analysis. *Journal of Allied Health Sciences Pakistan. Pp 98-104*

Omwirhiren, E. M and Ubanwa, A. O (2016). An Analysis of Misconceptions in Organic Chemistry Among Selected Senior Secondary School Students in Zaria Local Government Area of Kaduna State, Nigeria. International Journal of Education and Research Vol. 4 No. 7 July 2016 247.

Özcan, H., Çetin, G. H., and Koştur, I (2020). The Effect of PhET Simulation-based Instruction on 6th Grade Students' Achievement Regarding the Concept of Greenhouse Gas. Science Education International 31(4), 348-355 https://doi.org/10.33828/sei.v31.i4.3

Passey, D. (2020). Theories, theoretical and conceptual frameworks, models and constructs: Limiting research outcomes through misconceptions and misunderstandings. Studies in Technology Enhanced Learning, 1(1). https://doi.org/10.21428/8c225f6e.56810a1a

Piaget, J. (1970). *Structuralism*. New York: Basic Books.

Ritu, B. (2013). A study of errors and misconceptions in mathematics at the elementary school stage. Intentional Journal of Informative and Futuristic Research (IJIFR). ISSN (Online):2347-1697 Volume 1 Issue 1, (1-7)

Russel, M, O'Dwyer, L.M., Miranda, H. (2009), "Diagnosing Students' Misconceptions in Algebra: Results from an Experimental Pilot Study." Behavior Research Methods, vol. 41, no. 2, pp. 414-424, 2009.

Sarwadi, H.R. H and Masitah, S (2014). Understanding Students' Mathematical Errors and Misconceptions: The Case of Year 11 Repeating Students. Mathematics Education Trends and Research 1-10.

Seltman, H.J. (2018). Experimental Design and Analysis. E-book on the world wide web at http://www.stat.cmu.edu/~hseltman/309/Book/Book.pdf accessed on 5/04/2021

Soeharto, Csapó, B., Sarimanah, E., Dewi, F. I., Sabri, T. (2019). REVIEW OF STUDENTS' COMMON MISCONCEPTIONS IN SCIENCE AND THEIR DIAGNOSTIC ASSESSMENT TOOLS. Jurnal Pendidikan IPA Indonesia, JPII 8 (2) (2019) 247-266 http://journal.unnes.ac.id/index.php/jpii

Thekla, M., Gustafsson, M.S., Lindqvist, A., Renstrom, E. A., Ryan, M. K., and Morton, T. A. (2020). Defending the Sex/Gender Binary: The Role of Gender Identification and Need for Closure. Social Psychological and Personality Science 1-10. sagepub.com/journals-permissions DOI: 10.1177/1948550620937188. journals.sagepub.com/home/spp

Verniers, C. and Vala, J (2018) Justifying gender discrimination in the workplace: The mediating role of motherhood myths. PLoS ONE 13(1): e0190657. https://doi.org/10.1371/journal.pone.0190657 pmid:29315326

Zhou, Y and Skidmore, T.S. (2017). Reassessment of ANOVA Reporting Practices: Journal of Methods and Measurement in the Social Sciences, Vol. 8, No. 1, 3-19, 2017 3 A