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**EFFICACY OF HARKNESS TEACHING METHOD ON
STUDENT ACHIEVEMENT IN MATHEMATICS****Dr. Mercy Wanja Njagi**Department of Education, Chuka University, Kenya

ABSTRACT

Mathematics is very important in the society because it is the foundation of science, technology and engineering. Unfortunately low achievement in mathematics affects a large number of students due to various deficits that include attitudes, motivation, anxiety and instructional factors such as teaching methods. Creative and innovative forms of instruction that are more effective and student-centred need to be employed to improve the achievement in mathematics. The purpose of the study was to explore the efficacy of Harkness teaching method on students' achievement in mathematics. Quasi-experimental research design and specifically Solomon Four Group was used in the study. The target population comprised of secondary school students in Meru South Sub-county. The accessible population was Form three students in co-educational schools in the Sub-county. The sample size was 79 form three students from four secondary schools in the Sub-county. Simple random sampling was used to assign the selected schools to either experimental or control group. Mathematics Achievement Test was used as research instrument to measure students' achievement. Data was analysed using descriptive statistics such as mean, standard deviation and inferential statistics like *t*-test and ANOVA. The hypothesis was tested at 0.05 level of significance. The findings of the study showed that Harkness teaching method resulted in higher achievement so it had positive impact on students' achievement in mathematics. The research found that Harkness teaching method is an effective teaching method, which mathematics teachers should be encouraged to use when teaching mathematics in secondary schools and should be implemented in all teacher education programmes in Kenya.

Key words: Achievement, Harkness Teaching Method, Mathematics

1.1 Background of the Study

Mathematics offers core skills for life for it develops reasoning. It helps one to have an analytical mind that creates the ability to investigate and know the truth about the world. Mathematical skills are applied in the daily lives for everyday life requires some form of mathematical understanding and decision-making. Mathematics is

useful in science and technological activities as well as commerce, economics, education and even in humanities (Tella, 2008). Thus mathematics is fundamental to national prosperity in providing tools for understanding science, engineering, technology and economics. Studying mathematics not only will develop more engineers and scientists that require mathematics proficiency (Norris, 2012), but also produce citizens who can learn, think creatively and critically, have problem-solving ability and effective communication skills no matter their career fields. A solid foundation in mathematics and science develops and refines the skills of posing hypotheses, designing experiments and controls, analyzing data, recognizing patterns, seeking evidence, conclusions and proof, solving problems and seeking absolute while being open to new information (Lefkowitz, 2018). Students who are functional in mathematics are able to think independently in applied and abstract ways, and can reason, solve problems and assess risk. Despite the important role of mathematics and increasingly need for mathematical skills in the workplace, students consistently perform poorly in the subject.

Instructional strategies and methods are important for the achievement of students (Saritas & Akdemir, 2009) implying that a teaching method is a decisive factor in student achievement in mathematics. Instructional strategies are tools for reaching the set goals and objectives in instruction so teachers need to employ appropriate strategies to impact desired knowledge and skills on the learners. The teaching method used by instructor should help students to learn the desired course content and be able to develop achievable goals in future. It is important for educators to adopt creative and innovative instructional design techniques to attain higher achievement rates in mathematics (Rasmussen & Marrongelle, 2006). It takes effective teaching methods for learners to acquire most skills and increase in both knowledge and wisdom (Kwach, 2019). There is need of incorporating attention to the differing needs of students due to variety in readiness levels, interests and learning profiles because different students learn differently. This requires a change from the traditional formats to effective teaching methods to help address the needs of academically diverse learners in the increasingly diverse classrooms in order to ensure academic success for the full spectrum of learners.

Mathematics achievement is predictive to academic success, future employment, economic productivity (Williams, Clements, Oleinikova & Tarvin, 2003) and health outcomes (Rowlands, 2014). Educators and policy makers are increasingly recognizing importance of improving mathematics achievement due to wide applicability. Giving student both an opportunity to discover and invent new knowledge and an opportunity to practice what they have learned improves student achievement for they have a stronger conceptual understanding of connections between mathematical ideas (Grouws & Cebulla, 2000). Thus students need opportunities to practise what they are learning and to experience performing the kinds of tasks in which they are expected to demonstrate competence. Structuring instruction around carefully chosen problems, allowing students to interact when solving these problems, and then providing opportunities for them to share their solution methods result in increased achievement on problem-solving measures. Nizoloman (2013) indicate that the widespread low performance of students in secondary school mathematics can be ascribed largely to how instructions on mathematics are presented to students. To improve the students' achievement in mathematics, teachers should concentrate on providing opportunities for students to interact in problem-rich situations. Besides providing appropriate problem-rich situations, teachers must encourage students to find their own solution methods and give them opportunities to share and compare their solution methods and answers (Grouws & Cebulla, 2000).

Achievement in mathematics in Kenya at the Kenya Certificate of Secondary Education (KCSE) has remained particularly low (KNEC, 2015). Information in Table 1 indicates the national KCSE results for the years 2011 to 2017.

Table 1: Performance of Mathematics at KCSE from 2011 to 2017

| YEAR | PAPER 1 | Std. Deviation | PAPER 2 | Std. Deviation | OVERALL |
|------|---------|----------------|---------|----------------|---------|
| 2011 | 21.36 | 21.66 | 28.22 | 23.57 | 24.79 |
| 2012 | 29.46 | 23.98 | 27.86 | 23.18 | 28.66 |
| 2013 | 28.12 | 24.67 | 27.04 | 22.91 | 27.58 |
| 2014 | 24.54 | 20.77 | 23.50 | 23.16 | 24.02 |
| 2015 | 25.53 | 20.39 | 28.23 | 22.81 | 26.86 |
| 2016 | 23.74 | 21.24 | 17.84 | 21.09 | 20.78 |
| 2017 | 24.49 | 22.03 | 26.49 | 22.43 | 25.48 |

Source: KNEC (2017)

The KCSE results on Table 1 indicate that the performance in mathematics at Kenya is far below the 50% mean mark expected for a normal curve. In order to improve the achievement of learners in mathematics, teachers were advised to use a variety of teaching methods to effectively deliver the content (KNEC, 2015). Thus the need to incorporate innovative instructional practices such as Harkness method that creates a learning culture of enquiry and collaborative discussion thus providing students with opportunities for interaction and include every child in the classroom learning experience for better results.

Harkness is a teaching and learning method in which small classes of students sit around an oval table with the instructor to discuss ideas in an encouraging, open-minded environment with only occasional or minimal teacher intervention. Harkness focuses on the student as the centre of the learning process thus student-centered in which students take primary responsibility for driving the lesson forward, the exchange of information or ideas during a lesson and constructing their own understanding of the topic. Shampiro (2001) indicates that Harkness classroom goes beyond the mechanistic transmitting of information, and experientially teaches students how to learn, seek and discover information for themselves. The Harkness table offers a neutral, safe place for students to test out ideas, interpretations, and applications with peers and an expert who is the teacher. Consistent with Harkness as process based learning, this pedagogy values the 'truth' of education as the experience of discovery rather than the final destination of that experience, and for the teacher planning is for possibilities, not outcomes (Williams, 2014). Harkness teaching is leading student-centered discussions in class, finding ways to get students to make the discoveries for themselves, to get them to draw their own conclusions, to teach them how to consider all sides of an argument, and to make up their own minds based on analysis of the material at hand (Smith & Foley, 2009). The pedagogy of Harkness challenges students to achieve a higher level of engagement, to extract and construct their own meaning from the content, and then to share it courageously and articulately with their peers and teachers while gaining respect for the voices of others. Thus Harkness method focuses on having students initiate and build confidence in creativity, cooperation, collaboration, communication and critical thinking. Students are actively involved in learning by searching for knowledge and engage with the class by asking questions and contributing their own thoughts.

The principle underpinning the pedagogy of Harkness teaching is that the teacher is a facilitator and students are collaborative learners with ownership of the issues being discussed in the classroom. The teacher's role around the Harkness table is to guide discussion, encourage critical thinking, and help develop individual opinions. Harkness teacher will minimize the amount of information and answers they give directly to their students. Instead, they will give their students' resources in which the information and ideas can be found, or at the very least, they will help their students locate the necessary resources. Teachers using Harkness method may

sometimes step in to ask questions, redirect errant discussions, or provide some clarification, but they do not dictate the pacing, interpersonal dynamics, or even exact content of the lesson. Thus in the role of a facilitator, the teacher channelizes the discussion and also helps elevate the preliminary understanding the students bring into the classroom to higher order learning (George, 2017). Under the guidance of the teacher, the instruction in Harkness class focuses on the ideas brought to the table by the students themselves –what happens in the class depends on what the students have done before the class begins. Additionally, Harkness method allows the teacher to differentiate the lesson to fit all students' needs while helping students to develop new methods to help them learn in a way that makes sense to them.

Harkness method is more of an active, discussion-based learning style that requires students to take the lead and manage the lesson and discussions that follow. The students take the initiative to learn by themselves, gain preliminary understanding, and then come around a table to discuss what they learned (George, 2017). In order to engage students in learning the instructor need to provide them with activities that are innovative and challenging as well as purposeful. Harkness places students at the centre of the learning process and encourages them to learn from one another. Thus Harkness comes with an obligation that the student has to be prepared in advance which means having done the pre-reading or preparation and having thought about the content. Students who engage themselves with the Harkness class will finish with a greater sense of autonomy and empowerment, knowing that they know how to learn and with an increased ability to verbally articulate their questions and opinions in discussions (Shapiro, 2001). Thus Harkness students will come out with the important understanding of the power and necessity of listening, as well as the skills needed in order to be effective listeners. Not only do students grow in their understanding of content, they also develop invaluable communication skills as they navigate discussions and learn to acquire knowledge from others, digging deeper and using textual evidence to support their points (Smith & Foley, 2009).

According to Hattie (2009), Harkness encapsulates indicators of strong learning, clear learning intentions, obvious success criteria, a high level of peer work, and peer involvement in the task. Through the Harkness way of learning, students intrinsically develop essential qualities and values such as courage to speak up, compassion to listen, and empathy to understand. Geary and Atif (2013) posits that Harkness teaching can be more about creating an environment that fosters the discovery of content. Thus through this type of instruction, students learn to think critically, listen analytically, and interact respectfully. Harkness also promotes leadership characteristics such as strong self-awareness, self-regulation, motivation, empathy, and social skills to the students (Fradale, 2018). Based on the fact that Harkness teaching method fosters the development of critical thinking and provides a supportive academic forum in which students can express their ideas, there was need to investigate the efficacy of Harkness teaching method on students' achievement in mathematics in secondary schools. In this regard, Meru South sub-county in Kenya was selected for the purpose of this research.

1.2 Statement of the Problem

Mathematics equips students with uniquely powerful ways to describe, analyse and change the world. Mathematics knowledge is crucial to educational and financial success in contemporary society and thus mathematics achievement concern has persisted in many places worldwide. Mathematics achievement has been low due to various factors among them instructional factors such as teaching methods that play a major role in mathematical development. In attempt to improve students' mathematics achievement various new pedagogies are put in place. One such innovative teaching and learning methods is Harkness teaching method that may be employed for greater sense of autonomy and empowerment to relate to successful mathematics performance. Since Harkness method is a new and innovative way to get students engaged in the lesson and a form of novel

academic extension, there was need to investigate if using the Harkness teaching method could improve students' achievement in mathematics in secondary schools in Meru sub-county, Kenya.

1.3 Purpose of the Study

The purpose of the study was to explore the efficacy of Harkness teaching method on students' achievement in mathematics.

1.4 Objective

The objective of the study was to determine whether there is difference in achievement between the students that are exposed to Harkness teaching method and those exposed to conventional teaching method.

1.5 Hypothesis

There is no statistically significant difference in achievement in mathematics between students exposed to Harkness teaching method and those exposed to conventional teaching method.

2.0 Methodology

The Quasi-experimental research design and in particular Solomon Four Group was used in the study. The central feature of the Solomon four-group design is that participants are randomly assigned to either receive or not to receive a pretest and then randomly assigned to either a treatment or a comparison group. All participants then receive a posttest (Navarro & Siegel, 2018). This design contains two extra control groups, which serve to reduce the influence of confounding variables and allow the researcher to test whether the pretest itself has an effect on the subjects. It allows the researcher to exert complete control over the variables and allows the researcher to check that the pretest did not influence the results. The Solomon Four Group design is as follows:

| GROUP | PRETEST | TREATMENT | POSTTEST |
|-------|---------|-----------|----------|
| E1 | O1 | X | O2 |
| C1 | O3 | - | O4 |
| E2 | - | X | O5 |
| C1 | - | - | O6 |

Source: Shuttleworth, 2009.

The four groups had four different experiences:

- Group 1 (Experimental group, E1): Pre-test (O1), Treatment (X), Post-test (O2)
- Group 2 (Control group, C1): Pre-test (O3), No treatment (-), Post-test (O4)
- Group 3 (Experimental group, E2): No pretest (-), Treatment (X), Post-test (O5)
- Group 4 (Control group, C2): No pretest (-), No treatment (-), Post-test (O6)

The experimental groups were exposed to Harkness teaching method for a period of two weeks. The researcher trained the teachers in the experimental groups on the Harkness teaching method skills before the treatment. Pretest was administered before treatment and a post-test after two weeks treatment. Before the research, pretest was given to the students of these two classes to determine the prior knowledge and control the normality and the homogeneity of their distribution.

The unit of Sampling was the secondary school rather than individual learners because secondary schools operate as intact groups (Borg & Gall, 1989). Therefore each school was considered as one group. The list of the co-

educational schools in the sub-county was the sampling frame. Purposeful sampling was used to select four co-educational schools that had a class size of not more than 25 students. The sample of four selected co-educational schools in the sub-county was obtained. The number of participants in each school in each group was:

Group 1 (Experimental group, E1) N= 21

Group 2 (Control group, C1) N= 19

Group 3 (Experimental group, E2) N=15

Group 4 (Control group, C2) N=24

Therefore, the actual sample size in the research was 79 Form Three students.

The research instrument used in the study was Mathematics Achievement Test (MAT) to measure students' achievement level in the topic Binomial Expansion in form three syllabus. The MAT consisted of seven questions. Five questions had a score of four marks each and two questions were scored five marks each. The total score for the MAT was 30 marks. The MAT was scored, organized and coded for data analysis. Descriptive statistics such as percentages, means, standard deviation and inferential statistics such as One-way ANOVA were used to analyse the data.

The effectiveness of the treatment can be evaluated by comparisons between groups 1 and 2 and between groups 3 and 4.

3.0 Results and Discussion

In order to establish the efficacy of Harkness teaching method on students' achievement in mathematics, the MAT scores were coded and analysed. The section presents the research findings.

3.1 Mean Score for Pretest

The pretest was administered to enable the researcher to assess the similarity of groups before administration to the treatment. The pretest results for Experimental group one (E1) and Control group one (C1) were analysed then presented in Table 2.

Table 2: Pretest Mean Score on MAT for Experimental Group One (E1) and Control Group One (C1)

| GROUP | N | Mean | Std. Deviation |
|-------|----|--------|----------------|
| E1 | 21 | 2.7143 | 2.55231 |
| C1 | 19 | 3.2632 | 4.38231 |

The results on Table 2 indicate that the mean score for experimental group one was 2.7143 and that of control group one was 3.2632. The total attainable maximum score was 30. This shows that the mean scores of the two groups are different with the control group one having a higher mean score.

To test whether the pretest mean scores were significantly different for the two groups, an independent t-test was carried out. The results are given on Table 3.

Table 3: The t-test of Pretest Mean Score for E1 and C1

| Group | N | Mean | Std. Deviation | t | df |
|-------|----|--------|----------------|-------|----|
| E1 | 21 | 2.7143 | 2.55231 | | |
| C1 | 19 | 3.2632 | 4.38231 | 0.490 | 38 |

Information in Table 3 indicate that there was no significant difference in the mean scores of the two groups $t(38) = 0.490$. The value for $t_{critical}=2.021$ is greater than $t_{computed} = 0.490$. This implies that the mean scores of the two groups were not different. Thus the two groups had learners with similarly comparable characteristics suitable for the study. The two groups were equivalent before exposure to the treatment hence suitable for the study. The academic achievement in mathematics prior to the use of Harkness method of instruction was similar for experimental group and control group.

3.2 Mean Gain

The mean for pretest and posttest for Experimental Group one and Control Group one were calculated and compared. The results are indicated on Table 4.

Table 4: Mean Gain for E1 and C1

| Group | N | Mean for Pretest | Mean for Posttest | Mean Gain |
|-------|----|------------------|-------------------|-----------|
| E1 | 21 | 2.7143 | 16.4762 | 13.7619 |
| C1 | 19 | 3.2632 | 10.9474 | 7.6842 |

Information in Table 6 shows that the mean gain of students in experimental group one (13.7619) is higher as compared to the mean gain for students in control group one (7.6842). The mean gain for experimental group is more than one and half times higher than that of the control group. This implies that students taught using Harkness teaching method performed better than those that were exposed to conventional method. The findings concur with Rocca (2010) who pointed out that higher levels of student participation lead to improved learning outcomes, increased student motivation, and engagement in higher levels of thinking, including interpretation, analysis, and synthesis basing on her review of the literature on participation in post-secondary classrooms. Ferlazzo (2014) further noted that when student engagement is at a high level they perform better academically. The results also resonate with Caplan (2016) who established that students who began a network high school that used Harkness, with low achievement showed particular improvements in test scores and graduation rates.

3.3 Mean for Posttest

The mean for posttest for group E1, C1, E2 and C2 are presented in Table 5.

Table 5: Posttest Mean Score for Group E1, C1, E2 and C2

| GROUP | N | Mean |
|-------|----|---------|
| E1 | 21 | 16.4762 |
| C1 | 19 | 10.9474 |
| E2 | 15 | 17.4667 |
| C2 | 24 | 10.8750 |

The results on Table 5 reveal that the mean score of students in the experimental group one and control group one is 16.4762 and 10.9474 respectively. The mean score for experimental group one is higher than that of control group one. The mean score of students in the experimental group two and control group two is 17.4667 and 10.8750 respectively. Similarly the mean score for experimental group two is higher than that of control group two. The mean score for both experimental groups (E1 and E2) is higher after administration of treatment as

compared to control groups that did not receive treatment. The results from the study reveal that experimental groups performed significantly better than the control groups. The findings of the study are consistent with Allen (2009) who in his studies affirmed Harkness method's effectiveness in increasing students' retention and recall of material. Williams (2016) revealed that Harkness method can nurture genuine students' academic performance.

To find out whether the posttest mean were significantly different for the four groups One way ANOVA was conducted.

Table 6: ANOVA of Posttest Mean Score for Groups E1, E2, C1 and C2

| | Sum of Squares | df | Mean Square | F |
|----------------|----------------|----|-------------|-------|
| Between Groups | 709.811 | 3 | 236.604 | 6.165 |
| Within Groups | 2878.544 | 75 | 38.381 | |
| Total | 3588.354 | 78 | | |

The information on Table 6 indicates there was a significant difference between the means of the four groups, $F(3, 75) = 6.165$. The value for $F_{critical} = 2.758$ is less than $F_{computed} = 6.165$. This led to the rejection of the null hypothesis: there is no statistically significant difference in achievement in mathematics between students exposed to Harkness teaching method and those exposed to conventional teaching method. This implies there was a statistical significant increase in the achievement in students in the experimental group that were taught using Harkness teaching method. Therefore Harkness instructional method has proven to improve student achievement. The results concur with Caplan (2016) who found out those students who attended the network schools that used Harkness method achieved higher scores on a test that assessed core knowledge and complex problem-solving skills than similar students at conventional high schools.

To find out which groups differed significantly, Bonferroni Post Hoc test of multiple comparisons was carried out. Results of the analysis are presented in Table 7.

Table 7: Comparisons of Posttest Mean Scores

| (I) group | (J) group | Mean Difference (I-J) | Std. Error | Sig. |
|-----------|-----------|-----------------------|------------|-------|
| E1 | C1 | 5.52882* | 1.96155 | 0.031 |
| | E2 | -0.99048 | 2.09436 | 0.965 |
| | C2 | 5.60119* | 1.85117 | 0.017 |
| C1 | E1 | -5.52882* | 1.96155 | 0.031 |
| | E2 | -6.51930* | 2.13980 | 0.017 |
| | C2 | 0.07237 | 1.90243 | 1.000 |
| E2 | E1 | 0.99048 | 2.09436 | 0.965 |
| | C1 | 6.51930* | 2.13980 | 0.017 |
| | C2 | 6.59167* | 2.03909 | 0.010 |
| C2 | E1 | -5.60119* | 1.85117 | 0.017 |
| | C1 | -0.07237 | 1.90243 | 1.000 |
| | E2 | -6.59167* | 2.03909 | 0.010 |

*. The mean difference is significant at the 0.05 level

Information in Table 7 shows that the mean difference of groups E1 versus C1 and C2, E2 versus C1 and C2 were significant at 0.05 level. The difference could be attributed to the treatment (teaching using Harkness method) implying that the teaching method is effective and improves the performance.

4.0 Conclusion

From the findings of this research, it was evident that there was a difference in achievement in mathematics between the student exposed to Harkness teaching method and those exposed to conventional teaching methods. The students exposed to Harkness teaching method had higher mean score in that their performance was better thus it has proven to increase students' achievement. Since the experimental groups outperformed the control group, it can be concluded that Harkness teaching method is beneficial for it improves students' academic achievement. As a method of instruction, Harkness has a positive impact on student' performance in that it improves student achievement in mathematics. Harkness teaching method is effective and has potential for boosting student achievement so it should be incorporated in teaching mathematics in secondary schools in Kenya.

5.0 Recommendations

Educators need to implement Harkness as an alternative innovative and transformative teaching method to increase student engagement for quality and effective mathematics education. Since Harkness teaching method is a new instructional technique, in-service training should be organized for teachers to update their knowledge on how to adopt this student-centred teaching method for effective instruction and improved performance. Teachers need to embrace Harkness that is process-driven and skills-based since it is an adaptable pedagogy that inculcates skills to learners.

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