THE EFFECTIVENESS OF USING GEOGEBRA AND GRAPES ON STUDENTS' ACHIEVEMENT IN THE TEACHING AND LEARNING OF MATHEMATICS IN SECONDARY SCHOOLS IN BOMET COUNTY, KENYA

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Abstract:

Mathematics teaching and learning are crucial to the future of Kenya's knowledge economy and deserve a special focus in our education system. The objective of the study was to determine the effectiveness of using Grapes and GeoGebra on students' learning of graphs as compared to the traditional approach. This study was guided by Technology Acceptance Model (Davis, 1989). Technology Acceptance Model (TAM) explains computer-usage behavior that relates to reasons why some people use computers and their attitudes towards them. This study adopted Solomon four group experimental research design. The respondents were selected using both stratified and simple random sampling. Data was collected through the use of students' questionnaires, pre-test and post-test. Analysis of data was done using both descriptive and inferential statistics. For descriptive statistics, frequency tables, means and percentages were used. Anova, t-test and Multiple Regression Analysis were employed for the inferential statistics. The study found out that the students who were taught using Grapes and GeoGebra performed much better than those who were taught using the conventional method. It is recommended that ICT integration in the teaching of Mathematics should be included in the curriculum of pre-service teachers at the university level.

Keywords: GeoGebra, Grapes, achievement, Mathematics

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1. Introduction

The field of education has been affected by ICTs, which have undoubtedly affected teaching, learning, and research (Yusuf, 2005). A great deal of research has proven the benefits to the quality of education (Al-Ansari, 2006). ICTs have the potential to accelerate, enrich, and deepen skills, to motivate and engage students, to help relate school experience to work practices, create economic viability for tomorrow's workers, as well as strengthening teaching and helping schools change (Davis and Tearle, 1999; Lemke and Coughlin, 1998; cited by Yusuf, 2005). New instructional techniques that use ICTs provide a different modality of instruments. For the student, ICT use allows for increased individualization of learning. In schools where new technologies are used, students have access to tools that adjust to their attention span and provide valuable and immediate feedback for literacy enhancement (Emuku and Emuku, 1999 & 2000).

In a rapidly changing world, basic education is essential for an individual to be able to access and apply information. Such ability must find include ICTs in the global village.

Information and communication technologies (ICT) have become one of the fundamental building blocks of modern society. Many countries now regard mastering of the basic skills and concepts of ICT as an inevitable part of the core of education. To this end, various new models of education are evolving in response to the new opportunities that are becoming available by integrating ICT and in particular Web-based technologies, into the teaching and learning environment. The effective integration of such applications, however, depends to a large extent on teacher's familiarity and ability with the IT learning environment. Mathematics teachers need to know exactly how ICT is used as a teaching and learning tool, for their own purposes and to help students to use them.

The use of ICTs as part of the learning process can be subdivided into three different forms: as object, aspect, or medium (Plomp, Brummelhuis & Pelgrum, 1997). As an object, one refers to learning about ICTs as specific courses such as 'computer education.' The aim is computer literacy as an aspect, that refers to applications of ICTs in education similar to what is obtained in an industry. The use of ICTs in education, such as in computer-aided design and computer-aided manufacturing are examples. ICTs are considered as a medium whenever they are used to support teaching and learning. The use of ICT as a medium is rare (Plomp, 1997), in sub-Saharan Africa where the availability of resources is a major obstacle to the widespread integration of ICTs in education.

Various successful models of technology integration have been implemented in educational practices, such as participatory observation, project inquiry, simulated experiments, and curriculum integrations. In the science classroom, the advantages of teaching with ICT include more effectively delivering the dynamics of biological activities through multimedia animations, replacing risky experiments, providing access to web resources, enabling more representative scientific thinking, and enhancing

support for changing teachers' roles (Berger, Lu, Beizer, & Voss, 1994; Greenberg, Raphael, Keller, & Tobias, 1998; Peck &Dorricott, 1994).

Based on the evidence of how IT enriches teaching and learning, preparing teachers to integrate ICT into their lessons has become a high priority among action agendas for technology diffusion in K- 12 schools.

Although integrating IT into teaching has been advocated by educators for a decade, the longitudinal patterns of IT usage among school teachers indicate a below-average profile in many countries (Kozma, 2003; Plegrum, 2001). Apparently, a gap exists between IT affordances and teachers' intentions of use. The question of how best to bring about meaningful teacher development involving computer use is perplexing (Thomas, 2001). No clear set of preconditions is dramatically leading teachers to adopt IT in teaching. Therefore, understanding the underlying driving forces to persuade teachers to invoke technology integration significantly is necessary. When comparing differences in teachers' use of IT across grades and subjects, research found elementary teachers to be more apt to use computers on a regular basis with their students (Becker, Ravitz, & Wong, 1999), while science teachers reported the highest usage of IT in teaching (Barron, Kemker, Harmes, & Kalaydjian, 2003).

Infusing IT into teaching involves the process of determination as to where and how educational technologies create more meaningful learning opportunities for students. Such a determination aligns with teachers' cognitive judgments regarding the consequences of using IT, resulting in a set of beliefs and perceptions influencing teachers' decisions about technology integration.

In fact, most teachers have gained direct experiences with IT from teacher education or in-service training programs. Given the resources supported, the fact is that many school teachers still demonstrate a low enthusiasm for teaching with IT.

Information Communication and Technologies (ICTs) provide a window of opportunity for educational institutions and other organizations to harness and use technology to complement and support the teaching and learning process. E-learning is an example of the use of these ICT-supported teaching and learning methods whose use in educational institutions is gaining momentum with the passage of time (Omwenga, June 2004).

According to Reform Forum (April 2003) - Journal for Educational Reform in Namibia - Information Technology literacy is very different from being able to integrate technology into teaching to enhance learning. In other words, being "digitally fluent" means not only knowing how to use the technological tools, but also knowing how to construct things of significance with those tools. Teachers do not need to learn about technology; they need to learn how to use technology to enhance their learners' understanding and critical thinking skills. Enhancing basic information and communication skills like reading, writing, and speaking should be the focus of using ICT in education, not simply ICT literacy.

Muriithi (2005) has argued that in Kenya like most developing countries ICT usage is still limited to computer literacy training. She contends that the present ICT curriculum

merely deals with 'teaching about computers' and not how computers can be used to transform teaching and learning in our schools. In her thesis, she says that integration should consider learning pedagogy, the pattern of student use of ICT, and the extent of use in teaching and learning programmes.

The Technology principle of the NCTM (Principles and Standards for School Mathematics) (2000) identified the ''Technology Principle'' as one of the six principles of high-quality mathematics education. National Council of Teachers of Mathematics (2000) stated that Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning and that teachers should use technology to enhance their students' learning opportunities by selecting or creating mathematical tasks that take advantage of what technology can do efficiently. National Council of Teachers of Mathematics further suggested that students can develop a deeper understanding of mathematics with the appropriate use of technology. Technology can help support an investigation by students in every area of mathematics and allow them to focus on decision-making, reflection, reasoning and problem-solving.

2. Purpose and Objectives of the Study

The main purpose of this study was to investigate the effect of Geogebra and Grapes in the teaching and learning of Mathematics in Kenyan Secondary schools. The objective of this study was to determine the effectiveness of using Grapes and Geogebra on students' learning of graphs as compared to the traditional approach.

The following null hypothesis at alpha ($\acute{\alpha}=0.05$) level of significance:

HO₁: There is no significant difference between the use of Grapes and Geogebra and the traditional approach in teaching graphical work.

3. Theoretical Framework

This study was guided by Technology Acceptance Model (Davis, 1989). The model suggests that when users are presented with a new software package, a number of factors influences their decision about how and when they will use it. The main ones are:

- **Perceived usefulness** (PU) – *"the degree to which a person believes that using a particular system would enhance his or her job performance"*.
- **Perceived ease-of-use** (EOU) – *"the degree to which a person believes that using a particular system would be free from effort"*.

The technology acceptance model assumes that when someone forms an intention to act, they will be free to act without limitation. In the real world, there will be many constraints, such as limited ability, time constraints, environmental or organisational limits or unconscious habits which will limit the freedom to act. Concentration on the positive aspects of 'usefulness', both to the organisation and to the individual, and 'ease of use' will help users develop a positive attitude. It is in this area that early adopters can have a powerful influence on their conservative and pragmatic peers. The Technology

Acceptance Model is an information systems theory that models how users come to accept and use technology.

Davis et al. (1989) have developed a theory of action called the Technology Acceptance Model (TAM) to explain computer-usage behavior that relates to reasons why some people use computers and their attitudes towards them. Their model links the perceived usefulness and ease of use with attitude towards using ICT and actual use. They discovered that people's computer use was predicted by their intention to use it and that perceived usefulness was strongly linked to these intentions. A positive attitude towards performing certain behaviors was related to the perceived value of those behaviors. According to Malhotra and Galletta (1999), TAM has emerged as one of the most influential models in Information Systems research. The theoretical basis of TAM was Fishbein and Ajzen's (1975) Theory of Reasoned Action (TRA). TRA is a widely studied model from social psychology, which is concerned with the determinants of consciously intended behaviors.
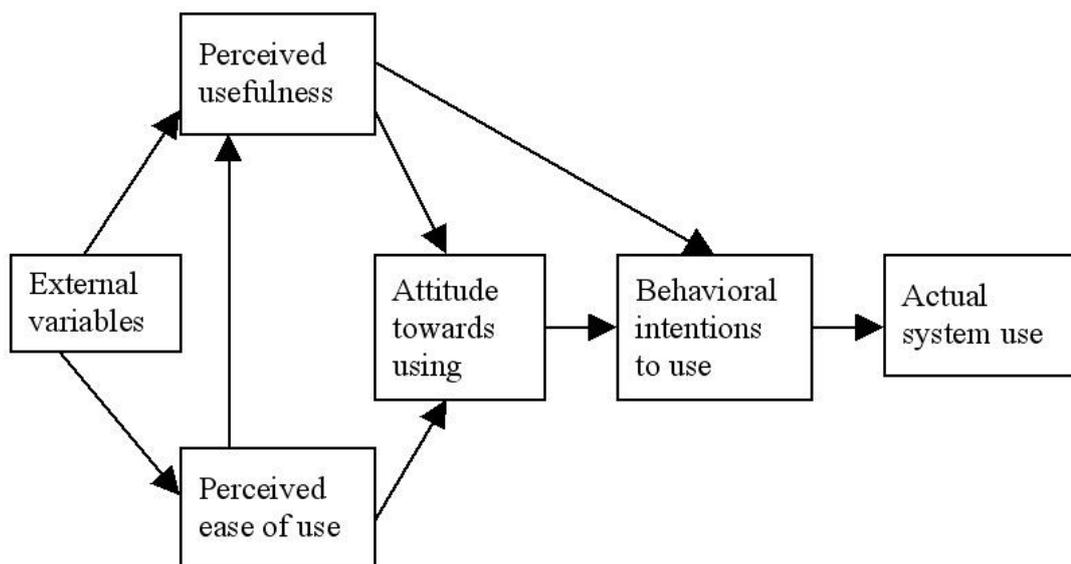

Figure 1.1: Technology Acceptance Model

Bagozzi, Davis and Warshaw say:

"Because new technologies such as personal computers are complex and an element of uncertainty exists in the minds of decision-makers with respect to the successful adoption of them, people form attitudes and intentions toward trying to learn to use the new technology prior to initiating efforts directed at using. Attitudes towards usage and intentions to use may be ill-formed or lacking in conviction or else may occur only after preliminary strivings to learn to use the technology evolve. Thus, actual usage may not be a direct or immediate consequence of such attitudes and intentions." (Bagozzi at al., 1992).

The research was also underpinned by the concept of teachers' pedagogical technology knowledge (PTK), developed by Thomas and Hong (2005), as a useful way to think in outline about what teachers need to know in order to teach mathematics well with technology.

4. Research Design and Methodology

This study adopted an experimental design. In an experiment, investigators may identify a sample and generalize to a population; however, the basic intent of an experimental design is to test the impact of a treatment (or an intervention) on an outcome, controlling for all other factors that might influence that outcome. As one form of control, researchers randomly assign individuals to groups. When one group receives a treatment and the other group does not, the experimenter can isolate whether it is the treatment and no other factors that influence the outcome (Creswell, 2011). The experimental method is a research plan conducted to determine the influence or impacts of a manipulation (Zulnaidi & Zamri, 2017).

Solomon Four-Group Design is a special case of 2×2 factorial design, this procedure involves the random assignment of participants to four groups. Pre-tests and treatments are varied for the four groups. All groups receive a post-test.

Table 4.1: Solomon Four-Group Design

Group	Pre-test	Treatment	Post-test
1. Pre-tested Experimental Group = E (R)	O_1	X	O_2
2. Pre-tested Control Group = C (R)	O_3		O_4
3. Unpre-tested Experimental Group = UE (R)		X	O_5
4. Unpre-tested Control Group = UC (R)			O_6

Source: Adapted from Maree (2016).

NB:
- X represents an exposure of a group to an experimental variable or event, the effects of which are to be measured.
- O represents an observation or measurement recorded on an instrument.
- X's and O's in a given row are applied to the same specific persons.
- The left-to-right dimension indicates the temporal order of procedures in the experiment.
- The symbol R indicates random assignment.

4.1 Target Population
The study was conducted in Bomet County. Form IV Secondary school students formed the target population. They were chosen for the study because there are many topics in Form IV that require a lot of graphical work. Therefore, the use of Grapes and GeoGebra software was handy in teaching graphical work.

4.2 Sampling Technique and Sample Size

Stratified random sampling was used to select the respondents. In this method, the population is divided into different strata (Segments). The items in each segment are homogeneous. Bomet County has got 5 sub counties namely Bomet East, Bomet Central, Chebalungu, Sotik and Konoin. Only four sub counties were picked at random. Schools in each sub county are stratified as per the performance in national examinations and gender. A school is picked at random from the homogenous strata. A total of 120 subjects randomly selected from four schools which are homogeneous were included in the research. The 120 subjects are assigned randomly to the four groups. Each group will comprise of 30 subjects. This design in its four-group form includes two control and two experimental groups, but the experimental groups receive the same experimental treatment. Only one of each of the two types is pretested and all four groups are post-tested at the conclusion of the experimental period. The assignment of subjects to all groups is random. Two of the groups receive the treatment and two do not. Furthermore, two of the groups receive a pretest and two do not. Within each treatment condition, one group is pretested and the other is not. By explicitly including testing as a factor in the design, it is possible to assess experimentally whether the testing threat is operating. According to Creswell (2011), there is a need to control the variables that might influence the outcome of the experimental design. Procedures to place control into experiments involve using covariates (e.g., pre-test scores) as moderating variables and controlling for their effects statistically, selecting homogeneous samples, or blocking the participants into subgroups or categories and analyzing the impact of each subgroup on the outcome (Creswell, 2008).

4.3 Research Instruments

Quantitative data collection techniques will be used for the study. The main data collection instruments will include the following:

1) Students' pre-test mathematics questions;
2) Students' post-test mathematics questions.

4.4 Research Variables

The independent variables were the traditional methods of teaching mathematics and the teaching of mathematics using Grapes and Geogebra. The dependent variables were the outcomes of the post-test scores.

4.5 Validity and Reliability of the Research Instruments

Content validity is the extent to which the sample items on the instrument provide adequate coverage of the topic under study. To ensure the content validity of an instrument, the researcher usually presents a provisional version to experts in the field for their comments before finalizing the instrument (Maree, 2016). This was done to ensure that the worksheet covered all the relevant areas of Geometry and graphical work.

Reliability refers to the degree of consistency or whether it can be relied upon to produce the same results when they are used by someone else (Scrimshaw, 1990:89). Reliability is the extent to which a test or procedure produces similar results under constant conditions on all occasions (Yin, 1994). The goal of reliability is to minimize the errors and biases in a study. The objective is to ensure that, if a later investigator followed exactly the same procedures, the same findings and conclusions would result.

The correlation coefficients between the scores of the responses from the questionnaire administered on the two different occasions were used to calculate the reliability coefficient using the Pearson product-moment correlation coefficient formula. The reliability coefficient for two sets of the students' questionnaire was 0.70 and 0.72 respectively. According to Kerlinger (1973) and Koul (1984), a positive correlation coefficient, r of 0.5 and above is a strong one and hence the research instruments were deemed reliable.

4.6 Data Analysis

Quantitative data analysis techniques were used. Quantitative data was used to put figures on what existed and what was representative and provide a context for the cases. Quantitative data was processed by editing, coding and analyzed using the SPSS. For descriptive statistics, percentages, frequencies and means were used to explain proportions. Inferential statistics such as Anova, t-test and regression analysis were used to understand relationships between different variables.

5. Findings

The findings are discussed according to the objective of the study.

5.1 The Effectiveness of Using Grapes and GeoGebra on Students' Learning of Graphs as Compared to the Traditional Approach

Before the introduction of the two different teaching methods, two groups of students were pretested. This was done to find out if the experimental and the control group had the same academic ability before the start of the experimental period. Thereafter all four groups were subjected to two different teaching methods. Upon the completion of the instructional course, all four groups of students took the same posttest. The control and experimental group received instruction covering the same concepts of graph work. The only differences between the groups were the manner in which the information was presented or explored. The experimental groups were taught graph work using Grapes and GeoGebra whereas the control groups were taught using the traditional method of pencil and paper or the board.

Table 5.1: Results of the Independent t-test on the
Pre-tests of Experimental and Control Groups

Group	N	Mean	SD	t-value	Sig(2-tailed)
Experimental Group	30	49.43	5.969	0.292	0.771
Control Group	30	48.97	6.387		

Both the experimental and the control groups were first measured on the dependent variable (pretest). Pretesting was done to ensure the two groups are of the same academic ability before being subjected to the two different teaching methods, namely the use of Grapes and GeoGebra and the traditional teaching method.

From Table 5.1 above, it can be seen that the pre-test scores for the experimental group is 49.43 whereas that of the control group is 48.97. The mean for the pre-test scores for the experimental group is slightly higher than that of the control group. The mean score difference between the two groups was 0.46.

To determine whether any significant differences existed between the mean of the pre-test scores of both the control and the experimental groups, an independent sample t-test was done.

The p-value was 0.771>0.05 indicating that the difference in the mean scores of the two groups was not significant. This implies that the two groups were homogenous. This result illustrated that both the students in the control and the experimental group were similar in their academic abilities before the treatment was administered. Before the introduction of the two teaching methods, the level of achievement among the students did not significantly differ between the experimental and the control group.

The two groups of students have the same academic ability before they are introduced to the two different teaching methods. One group was the experimental and was taught using Grapes and GeoGebra whereas the control group was taught using the traditional method.

Table 5.2: Test Scores for the Different Teaching Methods

Teaching Method	Mean	N	Std. Deviation
Pretest-Scores Before Introducing a Teaching Method	48.7250	60	5.97854
Traditional Method	55.5250	60	5.51449
Teaching Using Grapes and GeoGebra	75.3250	60	8.49853

From Table 5.2 above, it can be seen that before the introduction of a method of teaching the pretest mean was 48.7250. When the traditional method was used, the mean was 55.5250. This seems to suggest that the teaching method used had an effect on the post-test scores. There was a marked improvement on the scores of the students when the topic on graph work was taught using the conventional method. When the students were taught using grapes and GeoGebra, the mean of the post-test scores was 73.3250. This showed that the use of GeoGebra and Grapes was superior as compared to the use of the traditional method because it resulted in higher scores. Mathematical achievement among the students corresponded to the teaching method used. Students who studied in

the experimental group performed much better than the students who studied under the traditional teaching approach. Improvement in mathematical achievement was distinctly greater among students who studied using Grapes and GeoGebra than the level of mathematical achievement among students who studied under the traditional teaching approach. The use of GeoGebra and Grapes yield better scores as compared to the traditional method. This seems to suggest that the use of Grapes and GeoGebra resulted in a better understanding of the concepts of graph work as compared to the use of some concepts which appear to be abstract to the learners. Learners can easily conceptualize the concepts of geometry when they are taught using Grapes and GeoGebra as compared to when they are taught using the traditional approach. The use of Grapes and GeoGebra improves the academic achievements of the students because of appealing to more senses as compared to the traditional method of using paper and pencil to do graph work. The interactive nature of Grapes and GeoGebra increases the students' attention towards mathematics lessons which in most cases consist of abstract concepts which are predominantly found in mathematics and difficult to visualize when the traditional method is used to teach.

The use of Grapes and GeoGebra in teaching and learning mathematics assist the learners to develop problem-solving and thinking skills. This will enable the learners to construct their own learning in mathematics. It also enables the learners to discover and explore as they use Grapes and GeoGebra in doing exercises on graph work. The two softwares have a positive effect on retaining knowledge and help to construct and develop further knowledge in mathematics.

6. Discussions of the Results

The findings indicated that students who had learned graphical work using Grapes and GeoGebra were significantly better in their achievement compared to those who underwent the traditional approach. The findings further indicated that there was a significant improvement in the scores of the experimental group as compared to the control group. From these results, it can be seen that students gained from both approaches but the students in the experimental group appear to have a higher mean score compared to the control group. The students in the experimental group had superior scores compared to their counterparts who were taught using the conventional method. This, therefore, suggests that teaching using Grapes and GeoGebra is more effective than using the traditional method. Teaching using Grapes and GeoGebra places the student at the centre of the learning process. It attempts to address the individual differences among the learners according to their level of mathematical achievements. According to Kashti et al. (1997) and Yishraeli (2008) (as cited in Biashara, 2015) the characteristics of the traditional method are frontal, students receive information unilaterally and without using means of concrete and creative illustration, change of class location for group activity or any reciprocal type of activity.

The objective also involved testing of the hypothesis HO$_1$: *There is no significant difference between the use of Grapes and Geogebra and the traditional approach in teaching graphical work.*

On further analysis, the results of the independent t-test of the two groups showed that there was a significant difference between the mean performance score of the control group (mean=56.57, sd=6.084) compared to the experimental group (mean =80.40, p-value =0.000<0.05). The difference between the mean of the two post-test scores is 23.83 points. This finding indicated that students who had learned graphical work using Grapes and GeoGebra were significantly better in their achievement compared to those who underwent the traditional approach. This indicated that there was a significant improvement in the scores of the experimental group as compared to the control group. From these results, it can be seen that students gained from both approaches but the students in the experimental group appear to have a higher mean score compared to the control group. Therefore, the null hypothesis was rejected and the conclusion is "*there is a significant difference in achievement scores between the uses of Grapes and GeoGebra and the traditional approach in teaching graphical work.*"

7. Conclusion

The study found out that Grapes and GeoGebra software have proven to be very effective tools in enhancing mathematics teaching and learning of graph work as compared to the traditional method of using paper and pencil. Students were able to experience a hands-on and minds-on method of learning which had a positive effect in enabling them to understand concepts on graph work better rather than just being passive recipients of the teaching and learning process. At the same time Grapes and GeoGebra gave the students and the teacher an opportunity to work together collaboratively in exploring and visualizing new concepts. Grapes and GeoGebra are effective tools in assisting the students to develop discovery learning in mathematics. Grapes and GeoGebra also assist the learners in achieving the principles of constructivist learning while doing the graphical work. Constructivist teaching is based on the belief that learning occurs as learners are actively involved in a process of meaning and knowledge construction rather than passively receiving information. These findings are consistent with the findings of Twomey (1989) who recommended that a constructivist approach be used to create learners who are autonomous, inquisitive thinkers who question, investigate, and reason. A constructivist approach frees teachers to make decisions that will enhance and enrich students' development in these areas. Research suggests that constructivist teaching is an effective way to teach. It encourages active and meaningful learning and promotes responsibility and autonomy. Because constructivist teaching is beneficial in achieving desirable educational goals for students, it is important for teachers to grow professionally towards a constructivist practice (Gray, 2007).

8. Recommendations

From the research findings of the research that was conducted, the following are recommended:

1) Teachers should utilize the teaching and learning of mathematics using Grapes and GeoGebra in secondary schools as this study found out that this approach contributes to a better understanding and academic achievement in mathematics as compared to the traditional approach.

2) Ministry of Education should come in strongly to assist schools in the provision of computer hardware, software and training for all the teachers on the ICT integration. ICT infusion and integration require that teachers should have basic skills in ICT.

3) Schools should establish ICT centres where teachers can handle the teaching of mathematics better by the use of the new technology. ICT provides teachers with a range of new tools and materials to facilitate learning and also presents teachers with the potential to develop new teaching methods. The pedagogical rationale for promoting ICT in schools is concerned with the use of ICT in the teaching and learning process.

Conflict of Interest Statement
The authors declare no conflicts of interest.

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