EFFECTIVENESS OF LOCALIZED APPARATUS AND MOBILE APPLICATION IN TEACHING COSINE LAWS

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Abstract

The objective of this research was to assess the effectiveness of using a localized apparatus along with a mobile application for teaching the principles of cosine laws. It also intended to measure the students' level of interest in using the two interventions. Twenty (20) senior high school students served as the participants for each group. The study utilized custom-designed surveys to evaluate both the academic performance and the level of interest displayed by the students when engaging with the two instructional methods. In this study, various statistical techniques were employed, such as accuracy assessment, standard deviation analysis, mean calculations, t-tests for both dependent and independent data, and Spearman's rho correlation. The findings indicated a notable improvement in student performance following the implementation of localized apparatus and mobile application in teaching. It was also found that students who have used localized apparatus portrayed higher interest as compared with students who have used mobile application.

Keywords: *Pretest and Posttest performance Localized apparatus, mobile application, level of interest*

1.0 Introduction

Mathematics has been an important part of everyone's life. It is the foundation of all creations and the world cannot move without it. Even insects have their distinct way of using Mathematics in their everyday lives ("The Importance of Math", 2015). With this perceived importance of mathematics, the Department of Education is continuing its quest to develop students who are equipped with analytical and critical thinking skills. The Philippine Basic Education aims to improve students' performance in mathematics and science through its spiral curriculum ("DepEd's Spiral Curriculum", 2012). That is why Mathematics is taught at various levels including senior high school.

A study carried out by Patena and Dinglasan (2013) uncovered that Filipino students exhibit limited proficiency in Algebra and Trig-

onometry. Another study conducted by Gafoor and Kurukkan (2015) revealed that most of the respondents hate Mathematics because of its difficulty and the way their instructors deliver the subject matter.

Due to the ongoing issue of students' underperformance in Mathematics, the K+12 Curriculum has been designed in a way that tackles this challenge by prioritizing a student-centered approach and customized teaching methods. Its primary emphasis lies in fostering the best possible growth and advancement of Filipino students. It engages students in experiential learning, which can be immensely helpful for their lifelong learning ("Learner-Centered Education", 2015).

However, the implementation of the existing curriculum is still in progress. The researcher found a study conducted by Gumal (2016) that identified seven factors impacting the instruction of Mathematics in public schools in the Philippines. The researcher found two significant factors that are in line with this study. First, it revealed that the methods used by teachers were not aligned with the contemporary trends in teaching methodologies. Lastly, there was inadequate support from the administrators, resulting in having untrained teachers, which was caused by the lack of funds.

In the study of Guo (2022), a challenge emerged regarding the accurate application of the law of cosines. Some students attempting to solve problems using this law made errors in estimating or calculating the speeds of vehicles involved, leading to partially correct or incorrect solutions. Notably, a student from the younger group incorrectly applied the Pythagorean rule directly to the oblique triangle. Considering these findings, the study emphasizes the importance for teachers to adopt modern instructional methods, such as using mobile applications, and to incorporate contextualization through localized teaching in the field of mathematics. The study introduces and examines the use of localized apparatus and mobile applications to determine if they play a contributory role in students' success in mathematics, particularly in understanding the concept of the law of cosines.

This study aims not only to address problems but also to enhance disciplinary knowledge of the law of cosines. Most instructions addressing the understanding of the law of cosines focus more on solving real-life word problems through traditional paper and pen instructions. However, what makes this study unique is that it allows students to witness the practical application of the concept right in front of them through the utilization of localized apparatus and mobile applications.

Utilizing localized Mathematics instruction proves to be a successful strategy for both teaching and learning, as indicated by Garin et al. (2016). The use of indigenous materials and the development of authentic and contextualized learning materials are among the elements that can enhance students' academic achievements. Such an approach to teaching enables teachers to bring real-life experiences inside the classroom through less expensive materials available in the community.

Furthermore, the utilization of mobile applications inside the classroom to facilitate discussion is one of the modern techniques 21st-century teachers implement. Consequently, a study by Drigas and Pappas in 2015 revealed that the use of online and mobile applications has the potential to motivate students, resulting in an enjoyable and captivating learning experience in Mathematics classes.

The main objectives of this study were: a) to determine the accuracy of localized apparatus in the demonstration and experimentation of concepts related to Cosine Law; b) to find out if there is a significant difference between the pretest and post-test performance of the students after using the localized Cosine Law apparatus and mobile application; c) to determine the relationship between students' level of interest and their posttest performance.

2.0 Conceptual Framework of the Study

The research focused on the creation and application of localized apparatus and a mobile app in teaching concepts related to cosine laws. Figure 1 shows how the study works with emphasis on how the input, process, and output variables are connected.

In the diagram, the input stage involves a comprehensive discussion of the topic concerning the law of cosines. This phase sets the foundation for the subsequent stages of the study.

In the process stage, a series of activities occur, starting with the administration of a pretest to assess the students' baseline understanding. Subsequently, the study incorporates the use of localized apparatus and a mobile application as integral components of the teaching methodology.

The output stage yields valuable outcomes. Firstly, the students' post-test results are obtained, reflecting the impact of the instructional interventions on their understanding of cosine laws. Secondly, the study assesses the students' interest in both the localized apparatus and the mobile application, providing insights into the effectiveness of these tools in engaging learners.

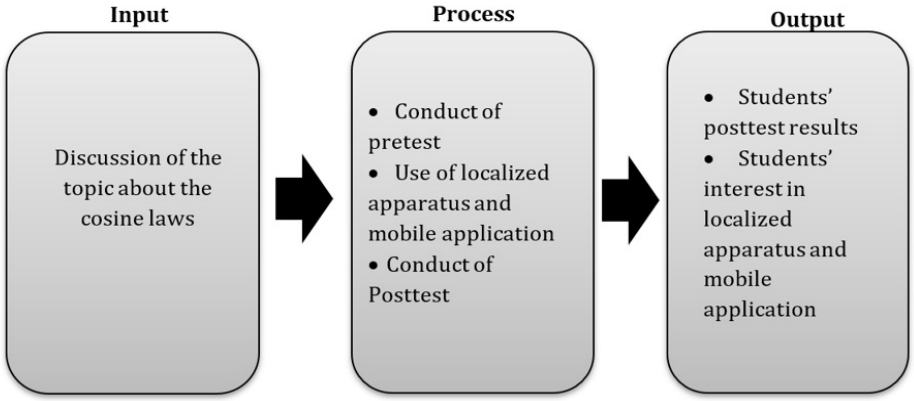

Figure 1. Diagram of the Conceptual Framework of the Study

3.0 Methods and Design

Research Design. The research design chosen for this research is descriptive and correlational in nature. It is descriptive because (1) it describes the accuracy and precision of the localized apparatus; (2) it also outlines the initial performance of the students in a pretest before utilizing the equipment and mobile application, as well as their performance in a posttest after implementing the interventions; (3) it describes the students' interest in using the approaches. The study is also correlational because it correlates the interest of the students in using localized apparatus and mobile applications in teaching cosine laws with their posttest performances.

Research Environment. This study took place at Apolinar B. Macias Memorial High School (ABMMHS) in Dauin, Negros Oriental.

Participants. The study was participated by the Grade 11 and 12 students of Apolinar B. Macias Memorial High School (ABMMHS) who were enrolled in the Technical Vocational and Livelihood Track, with majors in Computer Systems Servicing (TVL-CSS) and Humanities and Social Sciences (HUMSS). Only 20 students were enrolled in each year level. The research employed a cluster sampling method, specifically the two-stage sampling approach. The students were selected based on their performance in General Mathematics. A total of 20 students were chosen for each group—10 from Grade 11 and 10 from Grade 12. This selection ensured that both groups had a similar level of comprehension. As part of the research study, each group of 20 students was randomly assigned to either use the localized apparatus or the mobile application.

Research Instruments. An experiment was carried out to investigate the concepts of cosine laws, and a localized apparatus was constructed using locally available materials, such as recycled soft drink bottles. The data collected from these experiments were analyzed to assess the precision of the equipment used.

Additionally, a mobile application called "Law of Cosines" for Apple devices and "Law of Cosines Free" for Android devices was developed and made available for download on the App Store and Play Store, respectively. This app was used in conjunction with a self-made activity guide.

To evaluate the students' understanding of cosine laws, pretest and posttest questionnaires were crafted based on a Table of Specifications. These questionnaires were administered to the students to measure their conceptual understanding before and after using the localized apparatus and mobile application. A separate questionnaire was designed to gauge the students' interest in using these tools.

To validate the reliability of the questionnaires, experts were consulted, and a trial run involving 30 respondents, who were not part of the final sample, was conducted. Cronbach's alpha test was then used to authenticate the questionnaires for consistency and reliability. The results were analyzed with the assistance of a statistician.

Statistical Treatment of Data

The statistical tools used in the study are as follows:

Accuracy. This was used to determine the closeness of the analytical result done by the students when using the localized apparatus to the theoretical value during the experiment.

Standard deviation. This was used to determine how to spread out the results in terms of the students' performance in the pretest and posttest.

Mean. This was used to identify the extent of the students' performance during their pretest and posttest. It was also used to measure the extent of the students' interest in the use of localized apparatus and mobile application.

The t-test for dependent data. This was used to detect the significant difference between the pretest and posttest performances of the students. This was utilized since the data were in ratio scale.

The t-test for independent data. This was used to evaluate the significant difference in the post-test performances of the students. This was utilized since the data were in ratio scale.

Spearman rho. This was used to determine the degree of relationship between the students' interest in using localized apparatus

and mobile applications and their post-test performance. It was used since one of the variables is measured on an ordinal scale.

The proficiency level or academic performance at which the students were performing was based on the criteria stipulated in DepEd Order No. 8, s. 2015.

Research Procedure. Before conducting the activity and distributing the test questionnaires, an explanation of the purpose and significance of the study was provided to the students. The accuracy of the apparatus used in the study was tested by conducting ten trials, with variables "a" and "b" having different values in each trial. These trials were carried out simultaneously. The same procedures were applied to the group of students using the localized apparatus. Moreover, proficiency in utilizing the mobile application for the Law of Cosines was ensured to guarantee its proper functionality during the activity. To evaluate the reliability and validity of the questionnaires, a trial run involving thirty Grade 10 students from Apolinar B. Macias Memorial High School was undertaken. Before the pretest, an instructional session covering concepts related to cosine laws was conducted, wherein students were prompted to recall the formula and were given illustrative examples. Following the pretest, the procedures of the activity and the utilization of the localized apparatus and mobile application were explained, enabling students to manipulate them with the assistance of an experiment guide. One hour was allotted for the experiment and activity, during which students followed the instructions in the guide and answered the associated questions. A posttest was administered afterward, followed by the distribution of self-made questionnaires to measure students' interest in using the apparatus and the mobile application. Data collected from activity sheets and questionnaires were analyzed for accuracy and interpretation of the results.

4.0 Results and Discussion

Data Analysis. In this study, various statistical tools were employed to analyze the data. "Accuracy" was used to assess how closely students' analytical results matched theoretical values. "Standard deviation" measured the spread of results in terms of students' performance in the pretests and posttests, while "mean" helped gauge the students' overall performance and interest in using localized apparatus and mobile applications.

Two types of "t-tests" were used: one for dependent data to identify differences between te pretest and posttest performances, and another for independent data to

evaluate differences in the posttest performances. "Spearman Rho" was employed to determine the relationship between the students' interest and post-test performance. Additionally, the study assessed the students' proficiency levels based on the criteria outlined in DepEd Order No. 8, s 2015. These statistical methods helped analyze the effectiveness of localized apparatus and mobile applications in teaching. Results. This part of the study provides information about the accuracy of the localized apparatusv-for understanding the concepts of cosine laws, pre-test and post-test performances of the students before and after their use of localized apparatus and mobile application, and students' interest in using localized apparatus and mobile application. It processes the collected data by presenting, analyzing, and interpreting it in accordance with the issues outlined in the preceding parts. The findings are communicated using tables and explanatory text to facilitate understanding.Table 1 provides the data for the accuracy of the localized apparatus performed by the students and the researcher. The table also shows that the students and the researcher obtained fewer average percent errors while doing the experiment since the values are between 0.6089 and 1.4031, which are the lowest and the highest percent errors respectively. The table affirms that, among other groups, group 2 has the lowest average percent error while experimenting. It shows that this group has lesser average percent errors than that of the researcher. It follows that the localized apparatus used by the students in conducting their experiments on the concepts of cosine laws is accurate. It is also evident that the values are smaller and within the range of accepted error for apparatus, which is between 1% to 5%.

Table 1: *Data Comparison for Accuracy of the Localized Apparatus Performed by the Students and the Researcher*

Performed the Experiment	Average Percent Error (%)
Researcher	1.0753
Group 1	1.2372
Group 2	0.6089
Group 3	1.4031
Group 4	1.2275
Average Percent Error (%)	1.1104

Table 2: *Pretest Performance of the Students before Using Localized Apparatus and Mobile Application in the Concepts about Cosine Law*

Rating	Verbal Description	Localized Apparatus		Mobile Application	
		f	%	f	%
90% - 100%	Outstanding	18	90.00	13	65.00
85% - 89%	Very Satisfactory	2	10.00	1	5.00
80% - 84%	Satisfactory			2	10.00
75% - 79%	Fairly Satisfactory			1	5.00
Below 75%	Did Not Meet Expectations			3	15.00
Total		20	100.00	20	100.00
Average		93.90% (Outstanding)		90.70% (Outstanding)	
sd		3.32		10.45	

Legend:	Rating	Verbal Equivalent
	90% and above	Outstanding
	85% – 89%	Very Satisfactory
	80% – 84%	Satisfactory
	75% – 79%	Fairly Satisfactory
	74% down	Did Not Meet Expectations

Table 2 shows the pretest performance of the students before using the localized apparatus and mobile application for the concepts of cosine laws. It discloses that 90% of the students who utilized "localized apparatus" got a rating of 90% to 100%, which is higher compared to the 65% of students who utilized "mobile application." Data also indicate that both groups belong to the outstanding category. This means that the students, before using the localized apparatus and mobile application, already acquired an outstanding academic performance in the concepts of cosine laws.

Table 3: *Posttest Performance of the Students after Using Localized Apparatus and Mobile Application in the Concepts about Cosine Law*

Rating	Verbal Description	Localized Apparatus		Mobile Application	
		f	%	f	%
90% - 100%	Outstanding	20	100.00	18	90.00
85% - 89%	Very Satisfactory			2	10.00
Total		20	100.00	20	100.00
Average		96.65% (Outstanding)		96.75% (Outstanding)	
sd		2.94		4.67	

Legend:	Rating	Verbal Equivalent
	90% and above	Outstanding
	85% – 89%	Very Satisfactory
	80% – 84%	Satisfactory
	75% – 79%	Fairly Satisfactory
	74% down	Did Not Meet Expectations

Table 3 reflects the post-test performance of the students after using the localized apparatus and mobile application. The table also shows that 100% of the students who have used localized apparatus obtained an outstanding performance of 90% to 100%. Also, 90% of the students who have used the mobile application exhibited outstanding performance, while the remaining 10% of them got an 85%-89% performance rating with a verbal description of very satisfactory. Consequently, both groups have shown outstanding performance. It is also indicated that there is an increase in the students' average rating after using localized apparatus and mobile application.

Table 4: *Analysis Table on the Difference in the Pretest and Posttest Performance of the Students*

Strategies	Pretest (%)	Posttest (%)	Difference (%)	t-value	p-value	Decision	Remark
Localized Apparatus	93.90	96.65	2.75	3.420	0.001	Reject H_o	Significant
Mobile Application	90.70	96.75	6.05	3.765	0.001	Reject H_o	Significant

Level of significance = 0.05; df =19

Table 4 presents data on the teachers' usage of localized apparatus to teach the cosine laws, showing a 2.75% variance between students' pretest and posttest performances. The results indicate that the p-value (0.001) is below the significance threshold (0.05), leading to the rejection of the null hypothesis. This signifies a substantial difference in favor of the improved post-test performance of the students. These outcomes suggest that the enhanced student performance can be attributed to the use of localized apparatus.

Table 5. *Analysis Table on the Difference in the Posttest Performance of the Students Using Localized Apparatus and Mobile Application*

Strategies	Posttest	t-value	p-value	Decision	Remark
Localized Apparatus	96.65	0.081	0.936	Do not reject H_o	Not Significant
Mobile Application	96.75				

Level of significance = 0.05; df =18

The information presented in Table 5 reveals that the p-value (0.936) exceeds the significance threshold (0.05). Consequently, this result does not provide sufficient grounds to reject the null hypothesis. In other words, there is no substantial difference observed in the posttest performance of students who utilized localized apparatus as compared with those who used the mobile application. This result suggests that both strategies are equally effective, as indicated by the close similarity in post-test results for students in both groups.

Table 6: *Level of Interest of the Students in Both Approaches in Teaching Cosine Law*

Indicators	Localized Apparatus			Mobile Application		
	$w\bar{x}$	VD	Level of Interest	$w\bar{x}$	VD	Level of Interest
1. The use of apparatus/application makes me listen attentively to the teacher.	4.90	SA	VH	3.90	A	H
2. The use of localized apparatus/mobile application in Mathematics discussion is interesting.	4.80	SA	VH	4.00	A	H
3. The laws of cosine are very fascinating to me because of the use of localized apparatus/mobile application.	4.80	SA	VH	3.65	A	H
4. The activities made me realize that Mathematics is not merely a set of formulas that needs to be memorized.	4.75	SA	VH	3.90	A	H
5. The use of localized apparatus/mobile application makes me feel curious about the nature of Mathematics.	4.70	SA	VH	3.85	A	H
6. The use of localized apparatus or mobile application makes me feel excited as to what I'm going to find out, especially in the lesson about cosine laws.	4.70	SA	VH	3.60	A	H
7. I enjoyed using the localized apparatus/mobile application.	4.65	SA	VH	3.85	A	H
8. The localized apparatus/mobile application helps me focus on the discussion on the concepts of cosine laws.	4.50	SA	VH	3.60	A	H
9. The activity encouraged me to use my skills in manipulating objects.	4.45	SA	VH	3.55	A	H
10. I want to use these localized apparatus and mobile application in other concepts of Mathematics.	4.35	SA	VH	3.25	A	H
Composite	4.66	SA	VH	3.72	A	H

Legend: Scale	Verbal Description	Extent of Interest
4.21 – 5.00	Strongly Agree (SA)	Very High (VH)
3.41 – 4.20	Agree (A)	High (H)
2.61 – 3.40	Moderately Agree (MA)	Moderate (M)
1.81 – 2.60	Disagree (D)	Low (L)
1.00 – 1.80	Strongly Disagree (SD)	Very Low (VL

Table 6 shows the students' level of interest in both approaches to teaching cosine laws. It is shown that statement 2 has the highest weighted mean in both approaches, which is 4.80 and 4.00, respectively. This means that the discussions on cosine laws are made interesting because of the use of localized apparatus and mobile application. In addition, the data reveal that students who have utilized localized apparatus have a weighted mean of 4.66 whereas students who have used mobile applications obtain 3.72. These values imply that students who have used localized apparatus attained a very high level of interest, while students who have used mobile applications have a high level of interest in using the approach.

Table 7: *Relationship between the Level of Interest of the Students and Their Posttest Performance*

Variables	Computed r_s	p-value	Decision	Remark
Students' Interest in Their Teachers' Utilization of Localized Apparatus and Their Performance	0.120	0.616	Do not reject H_o	Not significant
Students' Interest in the Teachers' Utilization of Mobile Application and Their Performance	-0.497	0.026	Reject H_o	Significant

Level of significance = 0.05; df = 18

Legend:	Value of r	Strength of Relationship (Statistical Correlation, 2009)
Between	± 0.50 to ± 1.00	± strong relationship
Between	± 0.30 to ± 0.49	± moderate relationship
Between	± 0.10 to ± 0.29	± weak relationship
Between	± 0.01 to ± 0.09	± very weak relationship

The data shown in Table 7 indicate that there is no significant relationship ($p = 0.616 > \alpha = 0.05$) between the students' interest in their teachers' utilization of localized apparatus and their performance. This may connote that their interest cannot be considered as a determinant of their performance. This may be because their interest, as reflected in Table 7, is already very high, and based on the raw data, their individual interest is categorized as very high and high. The high performance of the students in the pretest and post-test can be explained since the discussion on the laws of cosine was made just recently and the retention of the lesson is still visible.

5.0 Discussion

The main objective of this research centers on assessing the effectiveness of teaching cosine laws

using localized apparatus and a mobile application among studentsat Apolinar B. Macias Memorial High School (ABMMHS) during the academic year 2018-2019. With this, the researcher designed an activity guide for both interventions and constructed a localized apparatus that made use of locally available materials. This is done for class experiments and to facilitate further understanding of the concepts of cosine laws. The accuracy of the measurements obtained from localized apparatus for the experiments and demonstrations was less than 5%, which implies that the localized apparatus used in the experiment was accurate in demonstrating the concepts of cosine laws. This result of accuracy is supported by the laboratory manual developed by the University of Iowa Department of Physics and Astronomy ("Percent Error Formula", 2017), which explains that the percent error very close to zero is good, meaning the value is close to the targeted value in the experiment. It also suggests that it is necessary to know the causes of the error, such as imprecision of the apparatus or estimations, or mistakes committed during the experiment.

It is a common practice to check the accuracy and precision of a new instrument brought into a laboratory to validate its functionality (Rodriguez, 2008). In this study, the accuracy of the localized apparatus was verified by performing a preliminaryexperiment before the actual experiment was conducted by the students.

The two groups of students, before utilizing localized apparatus and mobile application, already acquired an outstanding academic performance in the concepts of cosine laws as reflected in their pretest performance. There was progress after utilizing the interventions since there was an apparent increase in the number of students with outstanding performance from 90% during the pretest to 100% in the post-test. This means that after using the localized apparatus and mobile application, the students' performance in the concepts of cosine laws remained outstanding. There was no significant difference between the post-test performance of the students utilizing localized apparatus and their performance using the mobile application. This means that the effectiveness of both strategies was more or less the same. The results are similar to the findings of Perin (2011) and Zhang (2015) wherein the pretest and post-test results have shown an improvement in the students' learning of Mathematics using Mathematics applications. Similarly, Patron (2018) found that there is a significant difference between the pretest and post-test performances of the students after using localized materials to teach all the

basic concepts of fluid mechanics.

This result is also supported by Ariyanto et al. (2018) who concluded that education with the aid of mobile phone application (MPA) can have a positive impact on students' learning and can provide a great learning atmosphere both in class and outside the classroom.

Furthermore, data indicate that students who have used localized apparatus attained a very high level of interest, while students who have used mobile applications have a high level of interest in using the approach. It was also revealed that students who have used localized apparatus show enthusiasm and interest in doing the experiment. This result is supported by Sinco (2018) who studied about Strategic Intervention Materials, wherein it was revealed that students hold a favorable view of using Strategic Intervention Materials. The students derive enjoyment and interest from these materials, which in turn fosters a positive attitude toward examining additional scientific concepts.

The data also show results similar to the findings of Fabian et. al (2015) which suggest that students have a positive attitude toward using mobile devices in Mathematics classrooms.

In terms of the relationship between the students' level of interest and their post-test performance, it was found that no significant relationship exists between the students' interest in their teachers' utilization of localized apparatus and their performance. This connotes that their interest could be considered as a determinant of their performance. This might have been because their interest, as reflected in Table 7, was already very high, and based on the raw data, their individual interest was categorized as very high and high. On the other hand, a significant relationship was found between the students' interest in their teachers' utilization of mobile applications and their performance. Students who had higher performance manifested lower interest in their teachers' utilization of mobile applications. Correspondingly, students with lower performance showed higher interest in their teachers' utilization of mobile applications. The result of this study is supported by the testimonies of the students. The students who have high performance prefer using their computation skills to solve problems about cosine laws without the aid of the mobile application. However, students who have attained low performance prefer to use the mobile application since results can easily be generated. Logasov (n.d.) supports the findings stating that subject interest may contribute to motivation and enhance academic performance, although it is not a guarantee of success.

6.0 Conclusion

In evaluating the effectiveness of the localized apparatus and mobile application in teaching cosine laws, it is noteworthy to acknowledge a nuanced pattern among two distinct student groups. Surprisingly, those with heightened interest in the mobile application initially displayed lower performance compared to their counterparts who were less inclined towards its usage. However, upon further examination, both groups exhibited noticeable improvement in their average ratings after engaging with the localized apparatus and mobile application. This suggests that, while individual preferences and interest levels may influence the initial outcomes, both teaching approaches proved effective in enhancing students' understanding of cosine laws. The varying initial performances underscore the importance of considering diverse learning styles and preferences, urging a more nuanced interpretation of the overall effectiveness of the instructional methods employed in this study.

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