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Comparison of a Tablet Versus Computer-Based Classical Theatre Game Among 8-13 Year Children

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ABSTRACT In the last ten years, many studies have shown the advantages of videogames as tools for learning, engagement, raising awareness, or increasing interest in different fields. Schools are often the main focus of those studies. However, schools have either PCs or tablets in their classrooms, but rarely have both. That represents a severe limitation to videogame researchers since they can only deploy their video games in schools with the adequate platform for their video games. Researchers are therefore restricted in the number of schools in which they can conduct their experiments. In this paper, we study a videogame's effectiveness in increasing interest towards classical theatre, depending on the platform deployed (computer or mobile device). To that aim, we used ''The Courtesy of Spain,'' a point-and-click videogame created explicitly for this study, based on the play of the same name by Golden Age playwright Lope de Vega. To measure the abovementioned effectiveness, we implemented a quasi-experimental design with a comparison and an experimental group. The experiment involved 542 students between 8 and 13 years old from several middle schools in Madrid's Community (Spain). The study indicates that the videogame developed is equally effective on both devices (Sig <0.05). Our results will allow serious game developers to design one-fits-all games without jeopardizing their efficiency, which broadens the target schools where their games can be tested.

INDEX TERMS Mobile learning, learning, learning systems, student experiments.

I. INTRODUCTION

The perception that videogames are a waste of time is a thing of the past. Numerous studies have scientifically demonstrated the benefits of videogames in different aspects [1]–[4]. In particular, in the world of education, where paper and pens prevail, a well-developed and educationally oriented videogame is a useful learning tool [5]–[7]. Serious games, as they are commonly known, have shown to be efficient in computer science [8], programming [9], [10], social sciences [11], [12], geography [13], and even teaching social skills [14], among others. Moreover, there are also video games beyond the classic disciplines (although still very few) focused on artistic fields [15] such as the one used in the present study.

Furthermore, teaching educational content is not only goal of these games. Different studies indicate that serious games are valuable tools in raising awareness [7], [16]–[18], and increasing students' interest [8], [17], [19] in various areas.

However, most of the abovementioned studies include videogames deployed exclusively for computers [20]–[22], even though several studies have shown mobile devices offer great potential as learning tools [23]–[26].

Mobile devices and computers offer different user experiences. While user interaction with computers is based on a keyboard and mouse, mobile devices are fully tactile. These factors have certain implications: on the one hand the PC is more versatile when designing games (more possibilities in their controls) but, on the other hand, touch devices allow gestures. These gestures are more intuitive, natural, and more related to human communication [27]. Those differences directly influence on how the game's mechanics will work (and hence, its effectiveness). Thus, serious game researchers

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are forced to decide the platform on which the game will run in advance of developing their programs. Also, it reduces the number of target schools available for experimenting.

For example, in the Madrid region, where we conducted this research, most schools have a computer lab equipped with personal computers [23]. However, some schools (growing in number) have mobile devices (tablets) [28]. This fact traditionally forced serious games scholars to: 1) either design the game for one platform and exclude those centers that do not have it (which leads inevitably to biased studies), or 2) release a different version of the game for each platform, which, in some cases, duplicated the effort and jeopardized the validity of the comparison. In both circumstances, the consistency of the studies is at least somewhat compromised.

Given the above, it seems essential to evaluate whether the platform influences the effectiveness (in our case, in terms of increased interest) of serious games. At first glance, mobile devices seem to be more attractive to young people than computers. First, they are more familiar with their user experience since they use them every day [29]. Secondly, they may perceive mobile devices to be more modern than PCs[1] [30].

For the present study, we specifically created a videogame called ''The Courtesy of Spain'' [31], in collaboration with the National Classical Theatre Company, based on the play presented at the Matadero theatre in Madrid. The main objective of the game is to increase the interest of young people towards classical theatre.

This article is structured as follows. Section II presents the game design process. Section III summarizes the research questions in the study. Section IV includes the methodology of the experiment. Section V shows the results obtained, which are discussed in Section VI. Section VII includes the limitations of the study, and finally, Section VIII conclusions and future work.

II. GAME DESIGN

The videogame's primary goal is twofold: 1) to increase the interest towards classical theatre, and 2) to achieve similar effectiveness in increasing interest when it is deployed either on mobile devices or computers without increasing the development effort (measured with tests explained in section IV).

Regarding this first goal, the authors have previous experience creating serious games based on the performing arts [32]–[34]. The videogame ''The Courtesy of Spain'' was explicitly designed for the present study, in collaboration with the Spanish National Classical Theatre Company (CNTC) and based on the play of the same name by the Spanish playwright Lope de Vega (see Figure 1). Both videogame and graphic designers attended different rehearsals by the company and collaborated with the director. All the scenarios, music, and characters were based on the actual play performed at the Matadero theatre in Madrid.

[1] https://www.theguardian.com/society/2020/jan/30/most-children-own-mobile-phone-by-age-of-seven-study-finds

FIGURE 1. The Courtesy of Spain: the actual play vs. game start screen.

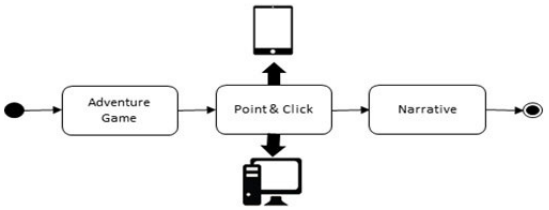

FIGURE 2. Game Design process.

A. TYPE OF GAME

The first design decision is the type of game to create. There are multiple types and depending on the educational goal, it is better to use one or another. This videogame stems from a theatre play, and thus it tells a story (see Figure 2). The dramatic structure used in classical theatre is well suited to adventure games [35] so we chose this type of videogame. Besides, experiencing a living character in a fictional world is pleasurable and can also be a learning experience [35]. Finally, it is essential to note that adventure games have already proved their efficiency in different educational videogames [15], [36] on both PCs [37], [38], and mobile devices [39].

B. INTERACTION SYSTEMS

As stated in the introduction section, mobile devices and computers offer different user experiences. Computers offer more options for mapping commands to a keyboard with more than one hundred keys and a mouse that allows you to position a pointer, press an icon with three different buttons, or use the center wheel. On the other hand, mobile devices offer a more

limited interface in terms of the number of commands we can map. One could think that it is like a mouse, but there are mouse functions that are not supported on a mobile device. If these functions are implemented in the game's design, they must be re-implemented or adapted to the touch interface. Besides, other functions included in mobile devices, such as the accelerometer or the GPS position, should be considered.

But the previous observations are not the only ones to be considered. The design of mobile applications is increasingly taking into account proxemics. In this case, touch devices offer more possibilities than computers. Mobile devices make social interactions easier and allow users to communicate with the environment through their sensors (GPS position, accelerometer, or camera). This contributes to a more satisfactory user experience [40]. Our design tries not to use these sensors (except the accelerometer in one mini-game) to minimize the proxemic difference between the two devices and to reduce the noise in the experiment.

Despite all the above-mentioned differences between the two devices, there is a way to minimize them: a point & click game. These games are easy to adapt to both platforms since most PC interaction is the mouse. We can substitute the mouse with touches on the screen. This makes the videogame similar to play on the two devices. As for the adaptation of the three mini-games in the game, two of them use the same mechanics for both platforms; the third one shares the design but uses a different interaction. It makes use of the tablet's oscilloscope, instead of the pointer position. This decision seeks to improve user experience with minimal impact on development time; otherwise, we would have discarded the minigame.

C. NARRATIVE

Finally, the videogame narrative; as previously stated, the game is based on the classical play "The Courtesy of Spain." Typically, classical plays follow a linear narrative, where the viewer has no transcendence in the evolution of the work. Having a linear narrative means that no matter how many times the work is performed, the script will not change, and what happens onstage will always be the same. In a narrative videogame, the player must have agency (the capacity to make decisions), and those decisions must have consequences. In this way, if a player plays the same game twice, different things can happen, depending on her decisions.

Since increasing interest in the original play is the game's educational goal, the researchers determined that players had to learn about the play's plot. However, it is crucial not to lose the agency mentioned above. Therefore, a balanced decision was required: 1) players go through the play's key points, but 2) they have enough freedom to choose and apparently live their own adventure.

In other words, the game allows the player to have freedom of decision, but her decisions must also have consequences in the game (i.e. some scenes are not shown), while always keeping in mind that the play's original script must be respected as much as possible.

In order to make the player aware that these responses have consequences, the character is provided with two elements that vary depending on the player's decisions: money and courtesy. Both may increase or decrease as the story unfolds, and this has consequences. For example, the courtesy level triggers different game paths, and money opens up specific options.

Finally, to improve the user's immersive experience, we brought voices to the characters, giving them personality. In addition, we included music throughout the different scenes based on the original play's soundtrack.

III. RESEARCH QUESTIONS

This study's main objective is to compare the effectiveness of a multi-platform videogame to increase interest towards classical theatre when played on tablets or computers.

As was mentioned in the introduction, previous studies have shown that educational videogames on PCs can increase players' interest in classical theatre. In this study, we intend to confirm, on the one hand, as previous studies suggest, whether a classical theatre-based PC videogame can increase players' interest towards classical theatre. On the other, we want to extend the study to a mobile device, testing whether a game played on a Tablet can also increase students' interest. Thus, the first research questions are:

RQ1.1: Can a multi-platform educational videogame increase players' interest towards classical theatre when played on a PC?

RQ1.2: Can a multi-platform educational videogame increase players' interest towards classical theatre when played on a Tablet?

As stated in the abstract, most serious games studies occur in schools [41]. Schools typically only have either PCs or Tablets in their classrooms. Comparing educational videogames' efficiency on the two platforms could shed light on whether a single multi-platform videogame is a useful all-purpose tool; in other words, the aim is to achieve a single videogame capable of being deployed in all the schools without compromising the study results. If that is so, scholars might prefer to design a single videogame and test it in any school in order to increase the target population. Therefore, we designed the next research question for this study:

RQ2: Is there any difference in the effectiveness of the videogame depending on the platform used?

In short, do those who play on tablets have their interest raised more than those who play on PCs, or if, conversely, PC players obtain a higher increment of interest?

IV. METHODOLOGY

A. PARTICIPANTS

The study involved N = 542 middle-school students from different schools in Madrid. All the students that claimed to be familiar with the play in advance were removed from the study (37 students). We also removed 2 students that

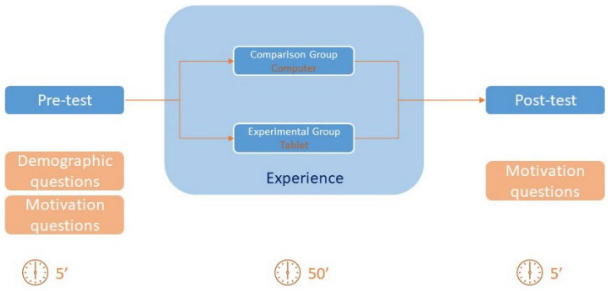

FIGURE 3. Experimental design of "The Courtesy of Spain" experiment.

didn't respond to this question. The gender ratio in the subsequent population (N = 503) was 51.3% male, and 48.7% female. The age of the participants was between 8 and 13 (median = 11).

97.22% of participants reported having a tablet or mobile device at home. Thus, playing the game on a tablet was not a technological challenge for them. 94.6% of the participants asserted that they have a computer device at home. This also shows us that there is going to be no problem with the computer game either.

The average of the participants' attendance at the theatre is 1.99 times in the last year. If we differentiate by groups, participants who have played on tablets attended an average of 2.02 while computer players attended an average of 1.95.

After developing a Student t-test, we can observe that there are no statistically significant differences (sig >0.05) between the two groups, so this will not be an impediment to the comparison of the groups.

B. EXPERIMENTAL DESIGN

The experiment has a quasi-experimental design (see Figure 3) which consists of three phases:

Pre-test

- **(5 mins).** Participants fill out a pre-test questionnaire before they find out which group they will join. This helps to avoid the effect of overexcitement experienced by students who leave their regular, everyday classrooms. On this form, students must provide the code given previously to anonymize them (see section IV.C for more detail). This code helps to pair the players' tests (pre- and post-). They will also give demographic information and answer questions to measure their interest in classical theatre and the abovementioned play (see section IV.C to more detail).
- **Experience (50 mins).** Participants are divided into two random groups. We try to ensure that the distribution is as homogeneous as possible (in terms of gender), and that the number of participants in the computer room is the same as the group that remains in the classroom. (see table 1 for distribution)
  - Experimental group (EG) (Tablet). They stay in the classroom. Each one receives a Tablet (mostly Lenovo TB-X103F) with the game pre-installed.

TABLE 1. Demographics of participants.

Group	Number of participants		Total
	Male	Female	
Tablet (T)	130 (50.4%)	127 (51.8%)	257 (51.1%)
Personal computer (PC)	128 (49.6%)	118 (48.2%)	246 (48.9%)
Total	51.3%	48.7%	503

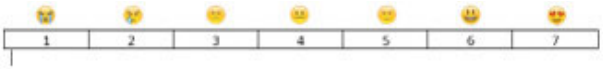

FIGURE 4. Example of a Likert-7 scale.

  - Comparison group (CG) (Computer). They go to the computer room, in whose equipment the game was previously installed.

Since a class' standard duration is 50 minutes, the game was designed to last 30 minutes. In addition, every student received headphones to maximize their concentration throughout the gameplay.

Post-test

- **(5 mins)**. At the end of the first game, participants fill out a second questionnaire. In this questionnaire, we ask the same interest questions as in the pre-test. If, for any reason, a participant, ten minutes before the end of the experiment, had not finished the game, they would still be invited to fill in the post-test. However, every student finished the game with enough time to complete the second questionnaire. Both questionnaires are described in the Instruments section (see section IV.C).

Once the post-test was completed, the participants could play the game again until the end of the session.

C. INSTRUMENTS

The students will do two tests during the experiment: one before the experience and one after it. To link the two tests anonymously, first, the students receive a sticker with a code.

The pre-test has two main sections. The first part includes demographic information, such as age and gender, whether the participants are already familiar with the play and the kind of electronic devices they have in their homes and how many times have they attended the theatre last year.

In the second part of this same test, we asked them four Likert-7 [42] scale questions (see fig 4) to measure their interest before the gaming experience. These four questions are not validated (as we explain in the limitations section), but we used them in other previous work, with high impact publications [15].

In the post-test, we only ask participants to write their code, and we ask the same four Likert-7 scale questions to measure their interest after the gaming experience (either on a Tablet or PC).

The interest questions are the following:

For data analysis, we carried out two different statistical tests: A Student t-test [43], [44] and a Mann-Whitney-Wilcoxon test [45], [46]. The prerequisite of the Student

TABLE 2. T-Student theatre attendance.

t	gl	Sig.
-.476	485.476	0.635*

*p<0.05

TABLE 3. Group statistics.

Descriptives	THEATRE ATTENDANCE		
	Mean	Dev.	Dev. Average error
PC	1.95	1.637	0.104
T	2.02	1.945	0.123

TABLE 4. Demographic questions.

Question	Possible answers
Age	Number
Gender	Male/Female
Did you know the plot of "The Courtesy of Spain" before today?	Yes/No
How many times have you gone to the theatre in the last year?	Number between 0 and infinite
Do you have a Tablet at home?	Yes/No
Do you have a cell phone?	Yes/No
Do you have a computer at home?	Yes/No

TABLE 5. Interest questions.

Question	Possible answers
Circle how much you like the theatre.	Likert-7 scale
Circle how much you want to go to see a classical play	Likert-7 scale
Circle how much you would like to see the play "The Courtesy of Spain "	Likert-7 scale
Circle how much you would like the school to take you to see plays	Likert-7 scale

t-test is a normal distribution between groups. We used this test to compare the two pre-test groups (see experimental design) to check homogeneity (whether both groups start at the same point). The Mann-Whitney-Wilcoxon test will compare the evolution of two independent samples. It is the non-parametric version of the usual Student t-test.

TABLE 6. Instruments used.

Instruments	Interest
Type	Likert-7 scale
How it is calculated	The sum of all 4 questions
Number of questions	4
Range	1-7

TABLE 7. Descriptives for computer.

Descriptives	Interest (I)		
	Mean (4-28)	Dev.	Dev. Average error
Pre-test	19.02	4.725	0.301
Post-test	21.37	4.694	0.299

TABLE 8. Student t-test computers.

N	Correlation	Sig.
246	0.716	0.000*

p<0.05

V. RESULTS

In order to answer the research questions, we will analyze the data in two steps: first we demonstrate the effectiveness in increasing intra-group interest (PC and Tablet) and, secondly, we analyze the inter-group (comparing both devices' effectiveness). For the interest of theatre variable (I), students' answers ranged from 1 to 7. Therefore, possible scores on this test (4 questions) ranged from 4 to 28 points. We used Cronbach's Alpha test to check the internal consistency of the scale, resulting in.712 for I in the pre-test.

A. EFFECTIVENESS BY DEVICE (INTRA-GROUP) IN INCREASING INTEREST IN CLASSICAL THEATRE (I)

As a first analysis, we performed a Student t-test (see Table 7 and 8) for related samples to observe the influence that the experience had on each group separately.

In the computer group, results show a statistically significant difference between the pre-test and the post-test ($p<.005$), with an increase of 2.35 in the post-test with regards to the pre-test.

Subsequently, we performed the same test for individuals who played the game with Tablets. Results (see Table 9 and 10) also demonstrate a statistically significant difference between the pre-test and the post-test in the Tablet group ($p<.005$) with an increase of 2.07 in the post-test with regards to the pre-test.

Thus, both activities exert a statistically significant upward influence. In other words, the use of the videogame, regardless of the platform used, increases participants' interest (I) in classical theatre. The increase in interest is higher in the comparison group (PC = 2.35) than in the experimental group (Tablet = 2.07).

TABLE 9. Descriptives tablets.

Descriptives	Interest (I)		
	Mean (4-28)	Dev.	Dev. Average error
Pre-test	18.79	5.129	0.320
Post-test	20.86	5.257	0.291

TABLE 10. Student T-test tablets.

N	Correlation	Sig.
257	0.644	0.000*

*p<0.05

TABLE 11. Student t-test for interest.

T	GL	Sig(Bilateral)	Mean differences
0.550	501	0.582*	0.392

*p<0.05

TABLE 12. Mann-Whitney for interest.

U	W	Z	Asym. Sig. (Bilateral)
30223.0	63376.0	0.857	0.392

B. COMPARING DIFFERENT DEVICES' OUTCOMES (INTER-GROUP)

Secondly, we carried out a comparative analysis between the two groups to determine how the device affects effectiveness. Thus, any initial differences that might exist between the two groups had to be considered. First, the Levene test of equality of variances indicated (p=.884, F=.021) that t-test results had to be analyzed assuming the equality of variances between groups. Thus, we compared the pre-test results using a Student t-test for independent samples: the type of device is the grouping variable and I is the variable tested. The results (p=.582) show no statistically significant differences between the groups' pre-tests. Therefore, we can compare both groups:

The Mann-Whitney test helps compare the growth in interest between groups. The type of device is the grouping variable and the difference between pre-test and post-test scores in I the test variable. The results confirm no statistically significant differences in the increase of interest after performing the activity using different devices.

C. RESEARCHERS' OBSERVATIONS

Most of the Tablet group's students, when finishing the post-test, asked to play another game or to access YouTube. However, the students who played on computers tended to play the game over and over again. Before data analysis, we wrongly supposed that the game would work better on computers than tablets. Nevertheless, as we can infer from the results, the videogame is effective on both devices without significant differences.

The activity took place in a calm environment. Nevertheless, the older the students were, the calmer the classroom was. It seems that the game created a more immersive environment for older students. This may indicate that this type of game is more suitable for teenage players than for younger players.

Although we distributed headphones to the participants, some decided to take them off because they were uncomfortable. Researchers observed that those participants were more easily distracted than their classmates with headphones. Indeed, players with headphones were more focused on finding the best option by themselves, while those without headphones preferred to share their progress with other classmates. There is massive evidence of the importance of the sound environment in commercial videogames, but it may also be essential for immersion in serious games.

Finally, once the participants finished the post-test, most of them decided to play again to explore the different paths and endings.

VI. DISCUSSION

This section will try to answer the research questions set out in section III by discussing the results section's evidence.

RQ1.1: Can a multi-platform educational videogame increase players' interest towards classical theatre when played on a PC?

RQ1.2: Can a multi-platform educational videogame increase players' interest towards classical theatre when played on a Tablet?

Yes. According to the statistical analysis carried out in the results section, both devices independently have been shown to significantly increase players' interest in the classical theatre (p<0.05).

Players who used a computer increased their interest by 2.37 points: from an average of 19.02 points before playing to 21.37 (max 28) points after the game. Student's t-test showed statistically significant differences (p=.000) between pre- and post-test. On the other hand, the group that used tablets started from an average score of 18.79 points. After the experiment, the score rose to 20.86, showing an increase of 2.07. Again, the Student t-test revealed statistically significant differences between the two tests.

Consequently, for both cases, we conclude that "The Courtesy of Spain" videogame produced an increment in students' interest in classical theatre.

RQ2: Is there any difference in the effectiveness of the videogame depending on the used platform?

No. The comparative analysis between the two platforms shows that the differences observed are not statistically significant (p>0.05), though both groups had homogeneous pre-tests (see section V.b).

These results demonstrate that it is possible to develop a serious game with the same efficiency to increase interest regardless of the game's platform. We are aware of our game's

particularity since it is a graphic adventure aimed at incrementing interest towards the theatre. However, our results may open a new path to designing serious games intended for experimentation: using a single game without taking into account the target school's platform. This fact will allow researchers to broaden the number of potential subjects of game-based experimentation in schools, which could result in more reliable experimental results.

In particular, a single design and a single line of development were enough to create a serious multi-platform game capable of raising students' interest in classical theatre.

VII. LIMITATIONS

There are some limitations to our experiment:

The study context is quite particular: raising interest in the theatre. Thus, transferring our conclusions to other areas is hazardous at best. Besides, the participants were students between 9 and 13 years old from several schools in a single city, making it difficult to generalize the results. The experiment was 50 minutes long, which makes it challenging to extrapolate long-term results. It would be interesting to conduct this research over a broader population spectrum over a more extended period to verify whether other statistically significant differences arise.

The instruments employed are also limited. We did not find any validated instruments for this project's proposal, so we had to develop them ad-hoc. These have a small number of items (4 items) due to the reduced time available for completing the experiment at the schools. In the future, it would be interesting to develop and validate an instrument. Moreover, the videogame had a series of limitations due to the limited budget available for its development.

Some students found the headphones uncomfortable, so they did not use them. Thus, some students played the game using headphones, while others did not. This difference might lead to bias in the final results.

VIII. CONCLUSION AND FUTURE WORK

We presented an experiment involving 542 students to determine whether a serious game could be deployed either on a Tablet or a PC without losing efficiency. To that aim, we developed ''The Courtesy of Spain'', a multi-platform videogame to increase interest towards classical theatre. No statistically significant differences were found in the game's efficiency when deployed on different platforms.

As mentioned in the introductory section, the Tablet seemed to be the most effective approach. However, our results contradict this first assumption. These results lead us to think that the devices may not directly influence students' perception of the game (at least in efficiency terms). On the contrary, it appears to be the videogame itself that exerts that influence. In this case, the content is more critical than the container.

The study's main conclusion is that researchers can use a single serious game for their experiments without having to worry about what kind of devices the target schools have. So far, serious games experiments had to choose between two possible audiences: either schools with Tablets in their classrooms or PCs. One-for-all games allow us to compare game effectiveness among the different populations. Thus, scholars could widen their experiments' target audiences by taking game design into consideration.

The results of this study also recommend caution when trying to change the deployment platform of a serious game. We are aware of the speed with which the sector moves, mainly driven by the industry. However, we would not recommend schools acquire mobile devices to get better results in serious games among their students that use PCs unless justified by other reasons. Therefore, those schools interested in using educational videogames should focus on buying better content rather than buying different devices. However, our study's limitations (see Section VII) make us cautious and highlight the need for more studies of this type before we can draw firm conclusions.

With these results, we think that if the type of game allows it, we could develop educational games for PC and Tablets at the same time, maximizing the potential audience of the game (as we have mentioned, PCs and laptops are still used in schools, in a significant percentage) as long as development costs do not increase.

As future work, we are preparing another experiment that will include a more extended intervention (in time) in which we can evaluate the longer-term results. Secondly, it is indispensable to replicate this study with videogames that focus on other types of arts such as dance or opera, to see if these results apply in these areas. Finally, the design presented in this paper is just the tip of the iceberg; we believe that other designs will achieve similar results.

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