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Research Article

Plickers to support similarities learning: An experience on 7th grade Portuguese basic education

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ABSTRACT

There are several educational software (ES) used in the classroom environment for the teaching and learning of geometric contents that are part of the Portuguese basic education mathematics program. There are studies that show that the use of this type of artifact has a fundamental role in the behavior of students, raising, among other aspects, a greater motivation for learning mathematics. The aim of this work is to explore and describe implications for the behavior and learning of students in the 7th grade of Portuguese basic education, in face of a pedagogical practice that involves carrying out tasks using ES Plickers, in the theme similarities of the domain geometry and measurement, throughout intervention carried out. The adopted methodology presents characteristics of a quasi-experimental study. The participants were 61 students from three classes of a school in the north of Portugal, followed during eight consecutive classes. A set of tasks using Plickers, tests and a questionnaire survey were used as instruments for data collection. The results point to positive increments, at a behavioral level, as well as in the evolution of learning, in view of the use of this methodology in the classroom.

Keywords: educational software, Plickers, similarities, behavior, learning

INTRODUCTION

Teachers are responsible for the methodologies they use in the classroom. We live in an era of resource diversification (González & Dueñas, 2009), innovation, and methodological transformation in the area of education (Parra-González et al., 2021). The use of technologies has become essential and education professionals play a key role in their application in the students' learning process. The effectiveness of using methodologies that require the use of innovative tools in the transmission of knowledge requires good training and mastery of the methodologies that teachers want to use (Parra González et al., 2021).

Since 2013, UNESCO has emphasized the need to use mobile devices in education, as well as in teacher training, so that the skills recommended for the 21st century can be developed (UNESCO, 2013). Its use offers

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teachers opportunities to expand their knowledge, as well as overcome barriers in its use (Junior, 2020). But does the use of educational software (ES) that are innovative and capable of helping teachers in the development of similarities content imply effective gains in the behavior and learning of students?

In this work we investigate the use of SE Plickers. Thomas et al. (2016) analyzed the relationship between educational performance, the rate of involvement and creativity of students when using Plickers application and concluded that its use improves the quality of students' knowledge. Gurisik and Demirkan (2019) also looked into the use of Plickers in classes and concluded that students consider it pleasant, verifying a positive contribution to the class, it allows immediate feedback of correct and incorrect answers, which leads students to correct then your mistakes. Demirkan et al. (2017) explored teachers' opinions about Plickers and concluded that its use saves time, increases general participation, competition, increases students' attention and motivation.

In Portugal, studies on the use of Plickers software in the classroom are rare, in addition to the fact that the use of technological tools by students in mathematics classes is scarce, particularly the use of mobile phones to carry out online research or resources to be used. mathematics or other applications (Silvestre & Jacinto, 2021). Hence our motivation to study this topic, in addition to the fact that this study is part of a more comprehensive research on the use of ES in the teaching of geometry and measurement (GM), having already published articles involving the use of Kahoot (Nunes et al., 2018), Modellus, Scratch (Nunes et al., 2020), GeoGebra, Texas Ti-Nsipre (Nunes et al., 2021b), Socrative, and Quizizz (Nunes et al., 2021a), among others.

This work consists of a teaching experience in the 7th grade of Portuguese basic education, with the purpose, not only of exploring and describing implications at a behavioral level, but also in the students' learning, when faced with the adoption of a pedagogical practice that involves the use of ES Plickers, in the approach of contents of the theme similarities, of the domain GM.

The work is structured in two distinct and complementary parts, the first of a theoretical nature and the second of an empirical study. in the theoretical foundation, we seek to explain some key concepts on the subject of the article, we research on active learning methodologies, focusing on gamification and we explore ES Plickers and the importance of its use in teaching and learning processes.

In the second part, we describe the empirical work, with regard to work planning: we characterized the sample, described the instruments used, described the methodological option, processed and analyzed the data, and discussed the results, seeking to report the theoretical perspective with the data obtained and finally, we present the conclusions.

STATE OF ART

In order to provide meaningful learning, the use of active learning methodologies has become essential, which, in general, stimulate students' involvement in the educational process and favor their critical and reflective capacity with regard to the contents to be addressed. These methodologies aim to promote students' proactivity, through their commitment to the educational process; linking learning to significant aspects of reality; the development of reasoning and skills to intervene in real life; collaboration and cooperation among participants (Lima, 2017). They also advocate those students need to understand that the contents to be addressed are related to what they have learned before, and above all, that they are relevant, verifiable and applicable in everyday life. The teacher has a role to present the culture and general learning in an attractive way and must also guide the student so that he/she builds his/her own competences, contents and transforms them into learning. Active learning methodologies essentially promote sociability and interactivity (González & Dueñas, 2009).

One of the active learning methodologies can be gamification, which comprises the application of different elements used in the development of electronic games, such as aesthetics, mechanics and dynamics, in other contexts unrelated to the game (Kapp, 2012). Deterding et al. (2011, p. 2) defined the gamification method as "the use of game design elements in non-game contexts". Safapour et al. (2019) concluded in their review of non-traditional teaching methods that the adoption of the gamification method causes an increase in the planning and problem-solving skills, creativity and motivation of students.

Recent studies have found benefits of gamification for teaching and learning processes. Parra-González et al. (2021) report that this method promotes an increase in motivation (Groening & Binnewies, 2019) and in the development of cooperative work. Safapour et al. (2019) mention as positive aspects, motivation during the class, cooperation between students, competition and scoring as forms of more complete involvement in learning, the interactions between the agents involved (González & Robles, 2019), which provide development of students' social skills. Gamification also favors interest and autonomy (Xi & Hamari, 2019), collaborative work (Perrotta et al., 2013), as well as the ability to solve problems (Kapp, 2012). All the aspects indicated cause a positive increase in students' ratings and in their school performance (Hursen & Bass, 2019).

Gómez-Carrasco et al. (2020) mention that the inclusion of gamification as a teaching practice does not in itself guarantee greater student motivation, it must aim to obtain learning results, so the type of tasks to be carried out must be appropriate to the content that is being taught. they intend to address and the characteristics of the students.

Plickers is an ES that can provide gamification. It allows the realization of questionnaires and/or assessments in real time, the use of which requires only a sheet of paper with a card for each student and a phone/smartphone/tablet with Internet for the teacher to scan the answers given. The response cards consist of a set of quick response (QR) codes that can be printed, where four options are indicated (A, B, C, and D) and the student's number at the top of each orientation. Students only need to look at the question posed by the teacher and orient their card in order to display the option they consider correct at the top of the QR code (Chanialidis, 2019). With the cell phone/smartphone/tablet camera, the teacher takes the readings and collects the students' responses through QR codes.

The use of Plickers produces relevant results for the teaching and learning processes. On the one hand, it can be used as an assessment tool, it reduces student anxiety, compared to traditional assessments, students prefer to use technology-supported classroom response systems instead of paper testing (Sahin, 2019) , increases attention, interest and motivation; but it can also be useful in teaching practice, in the sense of personalizing teaching to the students' rhythm, serving as a tool to improve assessment, allowing the visualization of content not absorbed by students, providing immediate feedback on the content evaluated and consecutively improving the teaching and learning processes (Ditzz & Gomes, 2017).

Drushlyak et al. (2020) list a set of advantages and disadvantages about using Plickers. At an organizational level, they have the advantages of being easy to use, the fact that they are free, do not require prior training from the student, do not require mobile devices other than the teacher, and the response cards can be reused; as disadvantages for the mathematics discipline, the inability to introduce mathematical formulas in the questions or answer options, the existence of only two types of closed answers–multiple choice and true/false, the maximum limit of questions per test (five), requires a stable access channel, both on the computer and on the mobile phone, and the fact that it is not suitable for large groups of students, as the camera cannot correct all response cards.

At a methodological level, Drushlyak et al. (2020) mention the following advantages of using Plickers: it intensifies the learning process, provides interactivity, causes a kind of fun for students, the fact that the teacher immediately visualizes the results, which are summarized in group or individual reports, which can be printed by question, students can change their answer until the final capture, the teacher can choose to disclose or not the students' results, and also a novelty that emerged very recently, which appeared as a disadvantage in the study of these authors is the fact that it can already be used in distance classes (e-learning mode).

METHOD

The aim of this work is to investigate whether the use of ES Plickers, a promoter of gamification, influences the behavior and learning of students who attend the 7th grade of Portuguese basic education, in contents of the theme similarities. To this end, we intend to answer the following research question (RQ):

RQ. To what extent does the use of SE Plickers in the theme similarities influence the behavior and learning of students?

To answer the research question, the quasi-experimental study was used as a method. Experimental and quasi-experimental research projects analyze whether there is a causal relationship between independent and dependent variables. In general, it is expected that the independent variable brings some variation or change in the dependent variable. However, a quasi-experimental study lacks random assignment of participants to the experimental group (EG) and the control group (CG), which is the main feature that distinguishes these studies from truly experimental designs. The control or comparison group participates only in the pre- and post-test, while EG, in addition to completing the tests, receives an experimental treatment. CG, which should be as similar as possible to EG, serves to capture what the results would be if no intervention had been implemented.

Participants

To answer the research question, three classes of the 7th year of schooling were monitored for eight consecutive classes, with 61 students, who were divided into two distinct groups, EG and CG. A teaching methodology was applied to CG using the expository method and the resolution of tasks from the manual adopted at the school, followed by the application of three tasks in paper format, for formative assessment; EG were taught exactly the same contents, with the same number of classes, but a different methodology was applied, using the resolution of pedagogical tasks from the manual adopted at the school, but with the use of ES Plickers, followed by the application of the tasks applied to CG for formative assessment, using Plickers. The objective was to make a comparative study of the two groups to answer the research question. The mathematics teacher of three classes is the same and corresponds to one of the authors of this article. The age and gender of participants are described in **Table 1**, distributed by group, thus characterizing our sample.

Table 1. Gender/age of participants by groups

Group	Gender		Age (years)				Total (%)
	Male	Female	12	13	14	15	
EG	15	25	9	22	7	2	66.0%
CG	11	10	7	7	5	2	34.0%
Total (%)	43.0%	57.0%	26.0%	47.5%	20.0%	6.5%	100.0%

Data Collection and Data Analysis

The study took place during the 2020/2021 school year, when the theme similarities were taught in the 7th grade. In a first phase, a questionnaire was developed, three pedagogical tasks and tests were applied, whose contents were validated by two higher education teachers and their empirical validation was carried out through a pilot study on a class. The aim of this preliminary study was to provide reliability and validity to the applied instruments, highlighting possible flaws. At this stage, it was possible to perceive, through the reactions of the participants in the pilot study, the suitability of the survey, the tasks and the tests to the phenomenon under study, whether questions asked were relevant to develop the intended contents, whether the students clearly understood questions, whether order was the most correct, among other aspects.

At the beginning of the similarities theme, a pre-test was applied to EG and CG, the objective of the pre-test was to ensure comparability between the two groups before the intervention, while the post-test allowed us to determine the immediate effects of the treatment experimental in the dependent variables. Therefore, the use of a CG allows us to verify whether the changes observed from the pre-test to the post-test, in EG, are the result of the different intervention with this group (Rogers & Révész, 2020).

Three tasks were also applied to make the formative assessment of the contents, each of the tasks consisted of five multiple choices or true/false questions. Task 1 aimed to assess the notion of similarity, with task 2 it was intended to investigate the criteria for similarity of triangles and with task 3 we intended to assess students' knowledge of similar polygons. In the last class used for this study, a post-test was applied, very similar to the pre-test, with the objective of verifying the evolution in the students' learning.

At the end of the intervention, a questionnaire was applied to the students (adapted from the behavior observation grid of the Faculdade de Motricidade Humana [Castro, 2012]), via email, using the Google Forms tool. This questionnaire allowed the evaluation of the domain related to behavior and performance in carrying out tasks. This domain is subdivided into subdomains, which may encompass categories, composed of items. The scale used to classify the items consisted of five points: "never", "rarely", "sometimes", "often" and

"always". The questionnaire consisted of 10 questions common to EG and CG, which focused on the following subdomains: presentation/posture during the task; task participation; task adjustment; initiative and suggestions; attitudes towards the task explained in **Table 2**.

Table 2. Behavior & performance in performing tasks

Subdomain	Category	Items
Presentation/posture during the task		Anxious
		Cooperator
		Distracted
		Motivated
		Active
		Passive
		Creative
Task participation	Accession	Volunteer
		With stimulus
		I make it to the end
		I do not adhere
	Attention	I pay attention to meaningful activities, more than 15 minutes
		I pay attention to activities that motivate me, between 5 and 15 minutes
		I pay attention to meaningful activities, less than 5 minutes
		I do not pay attention, requiring the teacher to repeat the instructions
	Impulsiveness	I do not show any impulsiveness
		I start the task before the teacher finishes the instruction
		I talk constantly during instruction
		I do not plan to perform the task
	Persistence	I strive in every task, & I do not give up
		I struggle in some situations
		I get discouraged and give up
Task adjustment		I present appropriate behaviors during the activity
		I exhibit maladaptive behaviors, but moderate them when I am called to attention
		I only adjust to situations for which I am motivated
		I do not adjust to tasks, showing impulsiveness/empathy
Initiative & suggestions		I take the initiative and make suggestions
		I take initiative and make suggestions through reinforcement
		I take initiative & make suggestions, but they are inappropriate for context
		I do not take the initiative or make suggestions
Attitude towards task	Motivation	I am committed & I give suggestions
		I get scared
		I give up
	Adequacy	Meet the task objectives

Note. Adapted from https://www.repository.utl.pt/bitstream/10400.5/7552/2/GOC_PDF.pdf

In the data processing, a descriptive analysis of the results obtained in the tasks, in the applied tests and in the surveys was carried out, using SPSS (version 25) and Excel (Office 2019). We analyzed the frequencies, in percentage points (pp) of the respondents' responses. To investigate the pre- and post-test measurements, the student's t-test was applied for EG and CG, and the frequencies and averages of the results were also used. For the null hypothesis, we consider the equality of the averages of the differences between the results obtained in the post-test and in the pre-test of EG and CG, alternatively, it is considered that the averages of the differences that compare the post-test with the pre-test they're not the same.

RESULTS

With regard to the presentation/attitude towards the task, in CG and EG, we highlighted in **Table 3** the responses whose difference between the groups stood out the most, where there was greater anxiety in less distraction in EG.

Table 3. Presentation/attitude towards the task by groups

	Anxious	Distracted
CG	5%	15%
EG	27%	3%
Difference	+22%	-12%

Regarding participation in tasks, by groups, we highlighted attention and persistence as attitudes, where there was greater variation between the two groups (**Table 4**).

Table 4. Tasks participation by groups

	Tasks participation							
	Attention		Persistence					
	I pay attention to meaningful activities more than 15 minutes	I pay attention to activities that motivate me between 5 & 15 minutes	I strive in every task & do not give up		I struggle in some situations		I get discouraged & give up	
			Sometimes	Always	Sometimes	Often	Never	Sometimes
CG	70%	20%	40%	40%	50%	20%	20%	35%
EG	41%	50%	18%	59%	15%	41%	56%	6%
Difference	**-29%**	**+30%**	**-22%**	**+19%**	**-35%**	**+21%**	**+36%**	**-29%**

We verified that in EG the students were attentive and solved the task with Plickers in less compared to CG. EG students showed greater effort in carrying out the task and less dropouts.

Table 5 explains the results that point to an improvement in the initiative and suggestions for EG students.

Table 5. Initiative & suggestions by groups

	Initiative & suggestions								
	I take initiative & make suggestions		I take initiative & make suggestions through reinforcement		I take initiative & make suggestions inappropriate for context		I do not take initiative or make suggestions		
	Sometimes	Always	Sometimes	Often	Never	Sometimes	Never	Rarely	Sometimes
CG	60%	0%	55%	25%	30%	35%	20%	35%	35%
EG	41%	18%	41%	35%	44%	6%	29%	27%	27%
Difference	**-19%**	**+18%**	**-14%**	**10%**	**14%**	**-29%**	**+9%**	**-8%**	**-8%**

As for the attitudes towards the tasks, by groups, the results reveal greater commitment, less fear, less dropouts and greater fulfillment of the tasks in EG (**Table 6**).

Table 6. Attitudes towards tasks by groups

	Attitudes towards tasks							
	Motivation						Adequacy	
	I am committed & I give suggestions		I get scared		I give up		Meet task objectives	
	Sometimes	Always	Never	Often	Never	Sometimes	Sometimes	Always
CG	40%	20%	45%	0%	35%	40%	30%	30%
EG	21%	38%	35%	9%	56%	3%	12%	59%
Difference	**-19%**	**+18%**	**-10%**	**+9%**	**+21%**	**-37%**	**-18%**	**+29%**

Using the averages of the results obtained in the tests and in the three tasks, it was possible to obtain **Figure 1** and **Figure 2**, where there is an evolution in learning both in CG and EG.

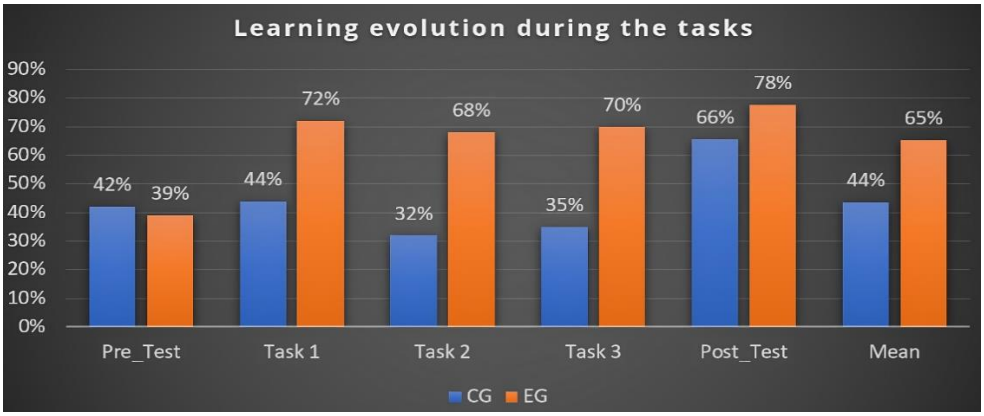

Figure 1. Evolution of learning during the performance of tasks/tests by group (Source: Authors)

To find out which of the groups had a greater evolution in learning, the differences between the results obtained in the post- and in pre- for EG and CG were compared using student's t-test. In view of the equality of variances (Levene test z=2.8, p=0.099) the equality of the means of the differences between EG (mean difference of 38.5) and CG (mean difference of 23.8) is rejected. Since t=-1.96 for a test value p=0.06 (U Mann-Whitney test has the standardized statistic 2.022, p=0.043, so the distribution of the two differences is different in EG (n=40, mean rank of 34.25) and in CG (n=21 and mean rank of 24.81), which supports the results of the comparison of means by the t-student test).

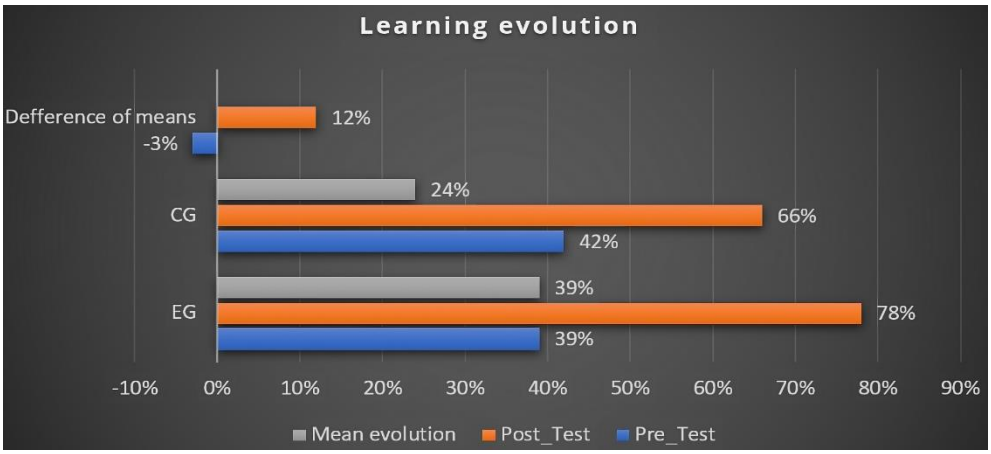

Figure 2. Evolution of learning by groups (Source: Authors)

DISCUSSION

Regarding the presentation/posture towards the task, from the results obtained and presented in **Table 3**, we infer that the use of tasks using ES Plickers triggered more anxiety in EG students (+22%), a divergent conclusion from the author Sahin (2019). One of the explanations could be the fact that it is a new ES, and the students are expectant about its use. In EG here was a greater concentration in performing tasks (-12% distracted), causing greater involvement in learning, in line with Safapour et al. (2019).

With regard to participation in tasks, by observing **Table 4**, in relation to attention while performing the tasks, we highlighted the fact that the use of Plickers in EG allowed students to solve the tasks that motivate them in less time (5-15 minutes), compared to the time spent by CG. Regarding the persistence in carrying out tasks, in EG we found a greater number of students who always tried in all tasks and did not give up (+19%), likewise, more students who tried in some situations frequently (+21%) and who never give up performing tasks (+36%). These data support that the use of ES Plickers allowed the completion of tasks in less time, when compared to carrying them out on paper, caused students to have greater persistence in carrying out tasks, less demotivation and dropout, consecutively greater participation in tasks, as the opinion of Wang and Tahir (2020).

With this study, we also observe in **Table 5** that the use of Plickers to develop similarities content triggered a more active participation in learning, we found that students took the initiative and gave suggestions in EG more than in CG (+18%). interventions inappropriate to the context decreased (-29%), as well as, in EG, we observed an increase in the number of active students (+9%) and a decrease in the inactivity of students (-8%). These results suggest that the use of ES Plickers promoted behaviors compatible with more active student learning, conclusions shared by González and Robles (2019).

Regarding attitudes towards tasks (**Table 6**), we highlight the fact that EG students showed more commitment (+18%), less fear (-10%), fewer dropouts (-37%) in carrying out tasks with Plickers and greater fulfillment of task objectives (+29%). These conclusions suggest that EG students performed the tasks with greater motivation and adequacy, results also mentioned by other authors such as Ditzz and Gomes (2017), González and Robles (2019), and Groening and Binnewies (2019).

With regard to the students' learning during the teaching of the theme similarities, it was possible to verify that the results obtained in the three tasks applied were always more favorable to EG, as we can see in **Figure**

1. After applying all the tasks and tests, there was an overall average evolution in learning, around 21% higher in EG, compared to CG.

The results achieved in the pre-test and post-test are explained in **Figure 2**. Through its analysis, we observed that initially, when carrying out the pre-test, CG obtained a superior result (42%) than EG (39%), although this difference is not significant (3%). Through this information we can see that the two groups had a very similar level of knowledge in relation to the theme similarities.

The post-test results indicate that after carrying out the tasks using Plickers in EG, the evolution in learning was around 39%, against 24% in CG. By student's t-test, we rejected the null hypothesis (equality of the means of differences between EG and CG) and concluded that the average evolution of the learning of EG was superior in about 15 pp compared to CG. We therefore concluded that the different methodology applied to EG resulted in a greater gain for students' learning (15 pp). This result is also shared by other authors, such as Ditzz and Gomes (2017), Drushlyak et al. (2020) who concluded that the use of SE Plickers intensifies and improves the students' learning process. Hursen and Bass (2019) and Nunes et al. (2021b) also mention that the use of ES that allow gamification causes a positive increase in student ratings and in their school performance.

CONCLUSIONS

We currently live in a time of constant change and when it comes to the use of technologies, this change is taking place at an impressive speed. Education professionals have already realized that today's society requires a different role for the teacher from the past, namely through the use of new methodologies and educational resources that have a positive impact on interest, motivation, involvement, participation and learning. from the students. Currently, several studies show that the use of ES, anchored in a good pedagogical model, has a fundamental role in the teaching and learning processes. With this work we wanted to assess the extent to which the use of ES Plickers in the theme similarities has an influence on students' behavior and learning. The results point to the following conclusions.

Regarding the behavior in EG compared to CG: we found greater anxiety in students and greater involvement in learning; completing tasks in less time, compared to the time spent on paper resolution; greater participation in tasks, attitude evidenced in greater persistence, less demotivation and fewer dropouts in their accomplishment; more active student learning; a positive increase in motivation and adequacy in carrying out tasks. Regarding learning: we found a greater gain in the learning of EG students, we concluded that the performance of tasks to develop similarities contents using ES Plickers, proved to be effective and contributed to a greater evolution of the students' learning, when compared to CG, who performed the tasks in paper format.

As a limitation to the study, there was the fact that the sample was small, so this teaching experience does not allow the generalization of results, however, it may be replicated in the future, with larger samples, to compare results and verify if there are significant differences. in relation to this investigation. In future works we intend to verify the effectiveness of this and other ES in GM, anchored in an active learning methodology, in order to verify if in different teachers, the application of tasks with ES resources makes or not the difference in the behavior and learning of the students.

We also highlight some non-controllable variables as limitations to the study, which may distort the results obtained, such as, for example, the fact that one of the teachers who applied this teaching experience was one of the authors of this article, the typology of the classroom, the dispositions of the students in the classroom and sometimes the absence of some students in the activities developed, as well as in the questionnaires. However, these situations were minimized by the fact that the groups were from the same school year, from the same school and the same teacher applied the tasks in the classroom, using the same number of classes for the purpose, in order to standardize the teaching experience in both groups as possible. This work corresponds to a small contribution of the investigation that we are carrying out, we intend to continue in the search for pedagogical methodologies using ES that prove to be positive and effective in the teaching and learning processes.

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Ethics declaration: Authors declared that the study was performed per the ethical standards in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Consent forms from school administration, parents, teachers, and students were obtained before the implementation phase.

Declaration of interest: Authors declare no competing interest.

Data availability: Data generated or analyzed during this study are available from the authors on request.

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