Effects of Game-Based Learning on Academic Performance and Student Interest

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Abstract. The goal of this paper is to study whether Game-Based Learning (GBL) can be used to improve academic performance and engagement. We present an experiment based on the design and deployment of a Monopoly-like board game, in the context of a primary school Geography curriculum, and look for improvements in students' academic performance and will to learn, interest, and positive motivation. The paper examines if this game had a statistically significant influence on students' performance, as well as how performance and interest are related and how performance differs between boys and girls. Results from the quantitative analysis of the data were positive to all the research queries: students' performance improved substantially after the game, while, the strong correlation between the two variables that resulted made evident the relation between the students' interest and performance.

Keywords: Game-based learning, geography, board games, Monopoly, open data.

1 Introduction

Geographical education contributes in formatting citizen's environmental awareness and fostering critical thinking [10]. Utilizing games in the learning process can meet these goals. Games develop skills such as cooperation, communication, critical thinking more than any other learning method. They highly engage players and motivate them. Game-based learning is designed to balance the content of the game and the game itself with the player's ability to apply game's concepts in real world ([6], [7], [8]). Prensky reports [5] that education and play have an interrelated relationship. Learning has rich content but little involvement, as opposed to games that lack educational content but engage students very much. Games offer an environment in which learning can thrive. Moreover, games introduce goals and procedures that a student must accomplish in order to evolve. Engagement is associated with learning outcomes [4] and motives are considered games' fundamental elements [1]. Therefore, educational games must be carefully designed in order to engage and motivate students. However, studies haven't found consistent evidence that games would affect academ-

ic performance [2]. Educational games can be considered promising learning tools, so if we implement them in classroom, we will combine interest and fun with learning [13]. Today's generation will no longer tolerate being a part of traditional, outdated education, hence, schools and businesses should use games to make learning fun and exciting, but also more effective [9].

Based on existing research, we investigated whether games can find their place in classroom and supplement traditional teaching, by offering an authentic learning environment. The reason behind this study was to find out whether a customized version of the classic board game Monopoly, called "Geopoly", which we implemented in class, affects students' academic performance and interest. More specifically, we sought answers to the following questions:

1. Does Geopoly game help students improve their academic performance in Geography?
2. Are there any differences between boys' and girls' performance?
3. Is there any relevance between interest and academic performance?
4. Which do students find more interesting: game or traditional lesson?

Then, we tested for the following hypotheses:

H1: Students who played the game achieved higher scores than those who attended class.

H2: There isn't any difference between boys' and girls' academic performance.

H3: Students who showed interest about the game achieved higher scores.

H4: Geopoly awakens an interest in Geography more than traditional teaching does.

To evaluate game's impact, we divided 43 6th grader elementary students (N=43) into two groups: experimental (game replaced traditional lesson) and control (students attended class) and used academic performance and interest as dependent measures and the game as the independent measure.

1.1 Method

Instructional design The present intervention aims to introduce students in Game-based learning theory and teach them European Geography alternatively. For this purpose, the classic board game "Monopoly" was adapted, renamed "Geopoly" and embedded in the classroom. Three chapters of school textbook were replaced by the game ("Residents and countries of Europe", "Cultural characteristics of European people" and "Monuments, sights and cultural heritage"). The dashboard was divided into four parts, each of one represented a European region (South, East, Scandinavia, North-Central) as described in the students' school book.

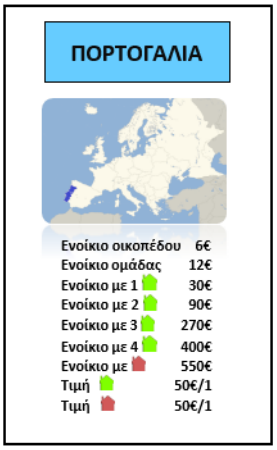
Countries were grouped by color based on their geographical position. At the right, we placed the country with the smallest area (in classic Monopoly, the country with the smallest value is placed at the right of each color group), so students can perceive the concept of relative position. Monopoly's cards were altered to serve our purpose (see Figure 1).

Cards Every game card showed the name of each country and its capital city, while peninsula and island countries were marked with an icon. Utility cards (normally railway stations and energy companies) were replaced with Europe's main sights and monuments. Thus, students linked easily each monument to its country and region.

Figure 1. The Geopoly game board and cards from the game

(a) The adapted game board with a 3D printed player token

(b) A monument card (utility card)



(c) A property card

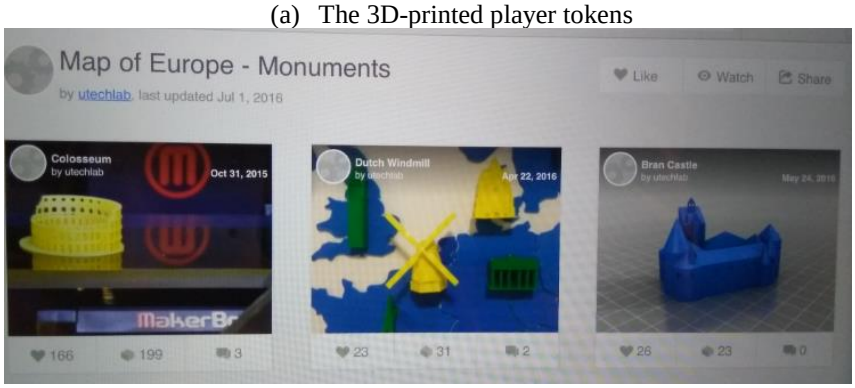
Upon completion of the educational intervention, students should be able to distinguish the four regions in which Europe is divided, obtain knowledge of a large number of countries and their capitals, distinguish peninsulas and island states, recognize that neighboring countries have common geomorphological and cultural characteris-

tics, compare countries' sizes, and perceive the concept of relative size recognize the main monuments of European culture. 43 6th grade students, participated in this intervention. Students were divided into two groups: experimental group (students played the game instead of attending class) and control group (students attended geography class).

Students in the Experimental group chose the monuments to be modeled and then used the Thingiverse.com website for 3d modeling, assisted by their teacher. All tokens were printed in a 3D printer and depict Europe's iconic landmarks (Colosseum, Big Ben, St Peter's Basilica, Eiffel Tower, Brandenburg's gate, Netherlands' windmills). Then, they took a written test, consisting of 5 exercises aligned with the learning goals of the intervention. Instructions and rules of the game were available on the "Geopoly" website created for this purpose. In the end of each game, teams posted the name of the winner name on the scoreboard.

Figure 2. 3D-printed tokens used in Geopoly

(a) The 3D-printed player tokens



(b) Thingiverse interface to choose and download 3D models

Teams played four consecutive times and each game lasted 40 minutes. In the end, for five minutes the class reflected on the game and their strategy. Right after the educational intervention, students were tested in a post-test, filled out an Intrinsic Motivation Inventory/IMI (common for the control and test groups), a multidimensional measurement device intended to assess participants subjective experience [14] related to a target activity in laboratory experiments, which it has been used in several experiments related to intrinsic motivation and self-regulation [11]. Finally, students evaluated the game, by answering a questionnaire.

Students in the Control group took a pre-test, were taught three chapters of school textbook and were tested again after. Finally, they filled out an IMI questionnaire and a lesson evaluation questionnaire.

2 Results

Statistical analysis was performed using SPSS. Data were collected from post – questionnaires, pre- and post-tests, Intrinsic Motivation Inventory and teacher observation; statistical processing provided the necessary answers to researcher's assumptions. Relationships between dependent variables (Performance, Gender, Interest, Anxiety, Perceptual Skill) and an independent variable (Geopoly game) were examined.

2.1 Performance

Overall performance To begin with, we tested for the dependent variable "performance". Results showed that both groups' scores were similar (~45/100). These below-average scores confirm our beliefs that students a have hard time studying Geography.

Table 1. Performance statistics before the intervention

Group (pre-test)	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Experimental	22	**45.3182**	20.61065	4.39420
Control	21	**45.00**	18.84144	4.11154

We conducted a parametric t-test in order to examine means' equivalence variance. Significance level (p=0,958) confirmed our first assumption: there isn't statistically significant difference between two groups' scores.

Table 2. Independent samples test (pre-test)

	Levene's Test for Equality of Variances		t-test for equality of means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. Error difference	95% confidence interval of the difference	
								Lower	Upper
Equal variances assumed	.294	.591	.053	41	.958	.32	6.03	-11.86	12.49
Equal variances not assumed			.053	40.928	.958	.32	6.01	-11.83	12.47

Consequently, we carried out a statistical check on the mean scores for each post tests and found out that both the scores for both groups improved. However, experimental group's scores were higher.

Table 3. Performance statistics after the intervention

Group (post-test)	N	Mean	Std. Deviation	Std. Error Mean
Experimental	22	78.50	18.44	3.93
Control	21	61.00	15.61	3.41

T-test attested that the game improved students' performance.

Table 4. Independent samples test (post-test)

	Levene's Test for Equality of Variances		t-test for equality of means						
Post-test	F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. Error difference	95% confidence interval of the difference	
								Lower	Upper
Equal variances assumed	1.375	.248	3.351	41	.002	17.500	5.223	6.95	28.05
Equal variances not assumed			3.364	40.439	.002	17.500	5.20	6.99	28.01

There is a difference between two groups' means, which is statistically significant ($p=0,02<0,05$). Statistical control verified our assumption that the game improved students' performance.

Gender difference Finally, we tested for a difference between the mean score of boys vs. girls.

Table 5. Performance vs. gender

		Experimental group		**Control group**	
	Gender	**N**	**Mean**	**N**	**Mean**
Pre-test	Girls	10	40.1	8	44.0
	Boys	12	49.6	13	45.6
Post-test	Girls	10	75.3	8	62.2
	Boys	12	81.1	13	60.2

There are differences in performance of boys - girls in both tests, which are not statistically significant as Levene's test for Equality of Variances showed.

Table 6. Performance statistics per gender

		Experimental group		**Control group**	
	Gender	**N**	**Mean**	**N**	**Mean**
Def	Girls	10	35.2	8	18.2
	Boys	12	21.5	13	26.3

Due to different scores' starting point, we will proceed to statistical control of students' means.

Table 7. Statistical analysis of student performance

	Levene's Test for Equality of Variances				
Control group	**F**	**Sig.**	**t**	**df**	**Sig. (2tailed)**
Equal variances assumed	1.632	.217	.352	19	**.728**
Equal variances not assumed			.398	18.992	.695
Experimental group					
Equal variances assumed	.304	.588	.572	20	**.574**
Equal variances not assumed			.556	16.226	.586

Control's group significance level (p=0,728>0,05) verifies our null hypothesis (boys' scores don't vary from girls'), same as experimental group (p=0,574>0,05).

Interest Moreover, we examined if game had an impact on students' interest about Geography. In order to find answers, we used data from IMI questionnaire which

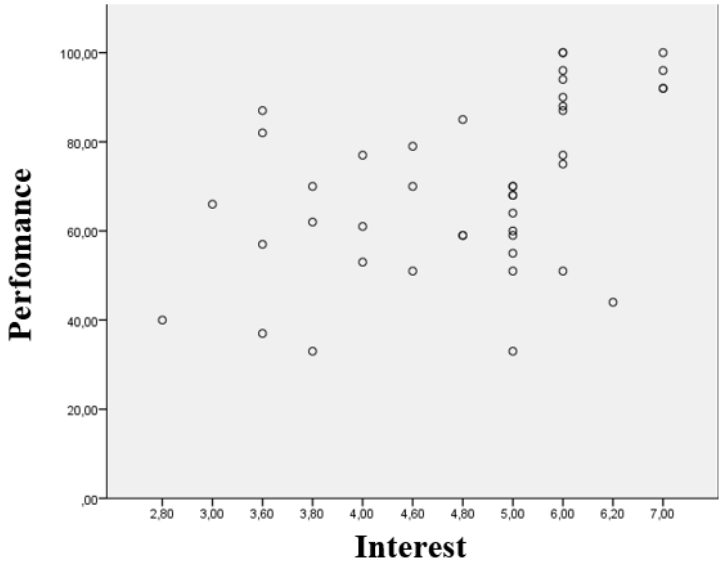
explores students' intrinsic motivation. Then, we correlated academic performance and interest, using Spearman's rank correlation.

Table 8. Spearman's rank correlation

		Post-test	**Interest (IMI)**
Post-test	**Correlation coefficient**	1.000	**.844**
	N	22	22
Interest (IMI)	**Correlation coefficient**	.844	1.000
	N	22	22

Spearman's test indicates that there is very strong positive correlation (r=0,844) between academic performance and interest.

Figure 3. Correlation between interest and performance



This scatterplot diagram presents that this high correlation is based on monotony. This correlation signifies that as students' interest increases, their performance increases as well.

Finally, we explored if students who played the game showed as much interest in Geography as students who attended traditional classroom, based on data extracted from IMI questionnaire. Results of the non-parametric Mann Whitney U test (48.500) highlighted that the experimental group has a higher average ranking (30.30) than the control group (13.31), thus mean rank of interest is higher on experimental group.

Table 9. Results from the non-parametric Mann Whitney U test

Group	N	Mean Rank
Experimental	22	30.30
Control	21	13.31

Significance level (p=0<0,05) rejects null hypothesis and confirms that students in the experimental group showed much more interest in Geography than those in the control group.

3 Discussion - conclusions

Despite the emergence of games as a learning tool, empirical results on their effect on academic performance and student interest in the curriculum remains limited. Our analysis revealed that students' first contact with a GBL environment was crowned with success with respect to both aims. Students couldn't believe that a game replaced the conventional lesson; their enthusiasm was evident from the first moment and all expressed the desire to repeat the process. This view was confirmed through the present study, as the analysis of the data indicates that learning goals, which were aligned with the curriculum, were achieved.

Differences between boys and girls are a common subject of research in recent years. There are significant gender differences in geography – related activities [12]. However, this survey's evidence suggested that there was no variation in performance of boys and girls.

A game-based learning environment offers significant potential for increasing motivation and student involvement [4]. Interest, anxiety [15] and perceptual ability, subcategories of internal motivation were measured to provide results on what motivates students. Students found the game interesting, and that caused a positive impact in their academic performance. Students collaborated well, thus we can conclude that playing, cultivated a breeding ground for the development of classroom collaboration. Cooperation, strategy, fun, interest enhanced educational process. Students realized that you can easily learn something and have fun at the same time. Learning and play have been combined to provide the best learning experience. More extensive research is proposed to introduce the GBL in the educational process, so that instructors and learners become more familiar with this learning theory.

At the same time, it would be interesting to adapt the game so that it can be used in other subjects such as Mathematics or Physics, in which performance of boys - girls differs greatly [3].

Finally, implementation of games in the educational environment presupposes their alignment with the curriculum, which is considered obsolete. More space should be provided for teachers to make the most of game's educational value by giving students the opportunity to broaden their knowledge and cultivate 21st century skills.

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