



Article

Using Big and Open Data to Generate Content for an Educational Game to Increase Student Performance and Interest

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Abstract: The goal of this paper is to utilize available big and open data sets to create content for a board and a digital game and implement an educational environment to improve students' familiarity with concepts and relations in the data and, in the process, academic performance and engagement. To this end, we used Wikipedia data to generate content for a Monopoly clone called Geopoly and designed a game-based learning experiment. Our research examines whether this game had any impact on the students' performance, which is related to identifying implied ranking and grouping mechanisms in the game, whether performance is correlated with interest and whether performance differs across genders. Student performance and knowledge about the relationships contained in the data improved significantly after playing the game, while the positive correlation between student interest and performance illustrated the relationship between them. This was also verified by a digital version of the game, evaluated by the students during the COVID-19 pandemic; initial results revealed that students found the game more attractive and rewarding than a traditional geography lesson.

Keywords: big data; open data; game-based learning; education; geography; board games; monopoly

1. Introduction

1.1. Big Data in (and for) Education

In recent years, the abundance of online learning solutions both for children and adults has increased interest in taking advantage of the data they create. Data related to school attendance, performance, engagement and other factors are too big to handle using conventional processing techniques; in addition to this, they offer the opportunity to identify relationships and trends, which may not be otherwise evident, using data mining algorithms. As a result, the field of data analytics seems to be the most appropriate means to exploit them [1], mostly to predict student performance or interest [2], visualize information in a dashboard [3], either for school usage or for policy makers [4] or even to identify cognitive states in real-time, such as interest and fatigue [5]. In this context, ethics awareness becomes of the essence, since data mining, especially in social media, has been criticized as a channel which caters for targeted advertising and may promote dubious behavioral shifts; given that big data effectively expands the scope of educational measurement [6], it is important to educate young students about the underlying mechanics, the source of available big data (not necessarily related to education) and the means to easily collect meaningful and dependable data sets. In our work, we utilize a Game-Based Learning (GBL) approach to educate young students not only with respect to a specific school course, but also about the relationships between different

entities from a Big Data set; this is also of great importance, in order to ensure that Big Data can be used and interpreted correctly [7–9].

World geography provides a handy introduction to Big Data for young students, since it incorporates diverse solitary information (e.g., Points of Interest, names of persons, etc.) and relational data, such as population and size; the latter is of major importance, since it can be used to illustrate ranking and grouping concepts between different entities (mainly countries or continents). Research shows that geographical education fosters critical thinking and increases environmental awareness [10–12]. Such skills can be cultivated by playing games, since cooperation, communication and critical thinking flourish in a playful environment, while games highly engage players and motivate the students [13–15]. Game-based learning [16] is designed to balance the content and mechanics of the game with the players' ability to transfer the concepts described in the game to the real world [17]; Prensky reports ([18]) that education and play are, indeed, interrelated. Conventional learning offers rich educational content, but little involvement, as opposed to games that sometimes promote fun, entertainment and flow, in exchange for reusable, transferable knowledge [19]. Moreover, the narrative of a game is manifested through goals and objectives that students have to accomplish in order to progress and succeed in it. Engagement is associated with learning outcomes [20–22] and motivation is considered games' fundamental elements [23]. Therefore, the game design process must be thorough, in order to engage and motivate students [24,25]. Even though literature reports quite a few examples of games having a positive effect on learning [26], this is not always the case [20]. Interest and fun can go hand in hand with learning, if we integrate educational games in the classroom, regardless of the students age group [27–30]. Today's generation have the unique opportunity to go beyond traditional means of education [31], hence, educators should use games to make learning fun and exciting but also more effective.

1.2. Monopoly as a Serious Game

Monopoly is one of the five most popular board games, licensed in more than 100 countries and printed in 37 languages [32]. Hasbro has produced or licensed different versions for cities, towns and regions and even for TV shows and Hollywood films. Custom-made Monopoly sets even played a role in World War II, when the British Secret Intelligence Service cooperated with the game's UK manufacturer to include genuine maps, compasses are real money, instead of the game's items, to sets delivered to prisoners via the Red Cross. Even though it is mostly considered an entertainment game, it was designed as an educational game, back in the early 20th century, by American game designer and author Elizabeth "Lizzie" Magie. Magie believed in the ideas of Henry George, an American political economist and journalist, who thought that land and natural resources should belong to the people who rent them, but never own them. Her game, called "Landlord's Game" consisted of a board with different properties, each with the distinct purchase price and rental value: in this context, the government charges tax not on profit or labor, but on the possession of land and whatever profit people can create through the investment of accumulated capital stays with them. Landlord's Game was initially rejected by one of the leading game manufacturers in the U.S. and was finally published by Parker Brothers in 1935, under the name "Monopoly" [33].

Monopoly employs several game objects and mechanics that associate them, the most prominent of which includes investing in property and re-using collected rent to build houses and hotels to increase the value of rent collected by visitors. In addition to property deeds, which correspond to street names in most Hasbro editions, players may invest in railroad stations and utility companies; as is the case with street properties, collecting more of the same kind increases the rent collected by visitors, along with the owner's chances of winning. Some of the squares in the board correspond to Chance cards, which may entail players paying taxes (players who have invested in many properties may be hurt substantially) or fund collection (redistribution of wealth) or even send players to Jail, where no rent can be collected by visitors in their properties. Chance cards, along with the use of dice that provide how many squares each player advances in each round, introduce a chance element;

despite that, the dominant strategy to increase a player's chances of winning is to move early, invest in many properties and try to save funds to invest in more expensive properties, usually positioned towards the end of the boards. In general, positioning of street properties on the board implies a ranking mechanism: the price to invest in each property increases as one moves along the board and, in turn, the rent collected by visitors and, hence, the player's return on investment, increases as well [34].

1.3. The Monopoly Game in Education

The original properties and game mechanics included on Monopoly cater for quite a few educational uses, the most obvious of them having to do with how to save and spend money in order to invest and that investments in property may not always lead to fiscal success. There are also mechanics related to social play, with players being able to lend money to bail out their friends and prevent them from going bankrupt and leaving the game.

Another obvious use has been in the context of land and lodging development: O'Halloran and Deale [35] designed a version of Monopoly, along with the relevant teaching material, where the objective is to maximize one's asset value by developing hotels and then blocks of hotels. An interesting addition to the usual game mechanics of the original game was that, as the game was played over a semester, players had the opportunity to research the actual real estate value of each property, as well as other emerging information regarding the market, and inform their property development decisions accordingly.

In the context of accounting education, Tanner and Lindquist extended Knechel's [36] idea and used Monopoly as a business simulation for a team-based project for university students. Students would form four-person teams, form a virtual company, agree on a mutual strategy and then face other "companies" in games of 24 turns per player. After the game, the members of each company analyzed the company's transactions as a whole, set up an accounting record and used a general ledger to keep track for each type of transaction: salaries, depreciation expenses, interest expenses and tax expenses. After the evaluation of the game, authors concluded that "students' attitudes towards financial accounting and learning, mutual concern and perceived achievement were very positive at the completion of the project" [37]. Shanklin and Ehlen [38] also worked with the original idea and saw that "the use of an engaging and unusual medium early in the principles course helps students build confidence and provides positive reinforcement of understanding in a course that undergraduate business students do not always enjoy".

Besides including Monopoly in courses where its mechanics make immediate sense, the game has been used in the context of other disciplines as well. Hastunar et al. [39] designed a modified version of the game, referring to food and everyday objects, instead of properties, and to points, instead of money, to teach English to students of 7th grade in Indonesia, while Inal and Cagiltay [40] assessed Monopoly, among other games, with children aged 7 to 9, noting the "clear and immediate feedback of the game" which resulted in increased flow.

An interesting concept, not necessarily restricted to school education, is that of creating Monopoly boards from open data. Gustafsson Friberger defines data games as "as games where gameplay and/or game content is based on real-world data external to the game, and where gameplay supports the exploration of and learning from this data" [41]; in the case of open data games, most of the game content (images, text, Points of Interest, etc.) comes from sources freely available for use, such as a governmental organization, NGO or data aggregator (e.g., Google's Public Data Explorer [42] and the European Union's Open Data Portal [43]). Dissemination of open data is important, since it can provide a substantial basis for argumentation in public speaking or policy making; in the context of education, it strengthens the connection between the concepts and facts taught at school with everyday life, and empowers students to make informed decisions in their life [27]. Friberger and Togelius [44] analyzed thoroughly the different kinds of information which can be used as properties in this context, from geographic data, which is typically readily available and easy to visualize, to demographic,

which can be sensitive (in terms of politics). They mention that real-time infrastructure data, such as flight information, are becoming increasingly available and may be more appealing to avid game players since it helps them relate to the actual providers of the data.

In our work, we wanted to examine whether the implied relations between entities and data contained in the game mechanics of Monopoly would help students identify the same relations between entities from a Big Data set. The subject of European geography was a straightforward choice, because it refers to a variety of numerical and reference data, typically associated with commercial versions of Monopoly. In addition to that, Monopoly entities are grouped using different colors, and ranked with respect to rent prices; we attempted to take advantage of these mechanisms to increase the students' comprehension of the relative size and population of each country and train them to identify those relations in the data. An additional game mechanic has to do with the positioning of the Monopoly entities on the board: even though in the original game there is no reference to any geographic positioning, in Geopoly the four sides of the board correspond to the region of Europe where each country resides. In order to create the required data and populate the board, we developed an automated infrastructure to retrieve data (country names, size and population, and landmarks) from Wikipedia, and create the Geopoly board respecting the grouping and ranking processes described earlier. The same approach can also be used with other Big Data sets, such as plants and animals (used in [27] in the context of a "Top Trumps" card game), where different numerical attributes (e.g., size, weight or life expectancy) or grouping elements (e.g., scientific classification, type of habitat or conservation status) may be used. As a result, we can create different versions of Monopoly to both familiarize students with concepts and relationships in Big Data sets and also follow and examine the learning objectives of the school curriculum, making it easier to integrate such a game in formal education practices.

1.4. Research Questions

Building upon previous research, we attempted to create an original learning environment by introducing game design and gameplay in the learning process. Our main objective was to study whether an adapted version of Monopoly integrated in the learning process would affect students' understanding of the relations contained in the game data and improve their academic performance and interest. More specifically, we wanted to identify whether:

1. the Geopoly game helps students get a better grasp of the underlying relationships contained in the data utilized to create the game content and, in the process, improves their academic performance in geography
2. there is significant difference between boys' and girls' performance
3. interest and academic performance, as measured in tests taken for a specific module or book chapter, are related
4. students find game-based learning more interesting than traditional teaching

Then, we created the following hypotheses:

Hypothesis 1 (H1): *Students who played the game performed better (i.e., received higher scores) than those who attended class.*

Hypothesis 2 (H2): *There is no significant difference in academic performance between boys and girls.*

Hypothesis 3 (H3): *Students who were interested in the game performed better.*

Hypothesis 4 (H4): *Geopoly results in increased interest in geography more than traditional teaching does.*

Taking into consideration all findings above, we wanted to further explore the impact of our game's digital version in students' interest. Due to the COVID-19 pandemic, schools were closed,

and students continued their lessons remotely, so they played the digital game at home and filled out an online questionnaire.

2. Method

2.1. Instructional Design

This intervention aims to introduce students in GBL practices, in the context of European geography. For this purpose, three chapters of the school textbook (“Residents and countries of Europe”, “Cultural characteristics of European people” and “Monuments, sights and cultural heritage”) were replaced by Geopoly.

2.1.1. Board

The four sides of the game board corresponded to regions of European (South, East, Scandinavia, North-Central), as described in the textbook, with countries being grouped by color based on their geographical position. The country with the smallest area was placed at the first position of each group, in accordance with classic Monopoly, where the property with the smallest price and rent is placed at the right of each color group; this mechanic was meant to help students perceive the concept of relative position and size.

2.1.2. Cards

Each card (Figure 1) demonstrated the name of the country and its capital, while peninsula and island countries were marked with a special icon. Europe’s main sights and monuments replaced railway stations and utility companies to help students associate them with their respective country and region.



Figure 1. The Geopoly game board and cards from the game [45]. (a) The adapted game board and 3D printed player tokens; (b) a monument card (utility card); (c) a property card.

2.1.3. Tokens

In order to engage students more in the process, we asked them to design the tokens which depict Europe’s famous landmarks (Colosseum, Big Ben, St Peter’s Basilica, Eiffel Tower, Brandenburg’s gate, windmills in the Netherlands—see Figure 2).

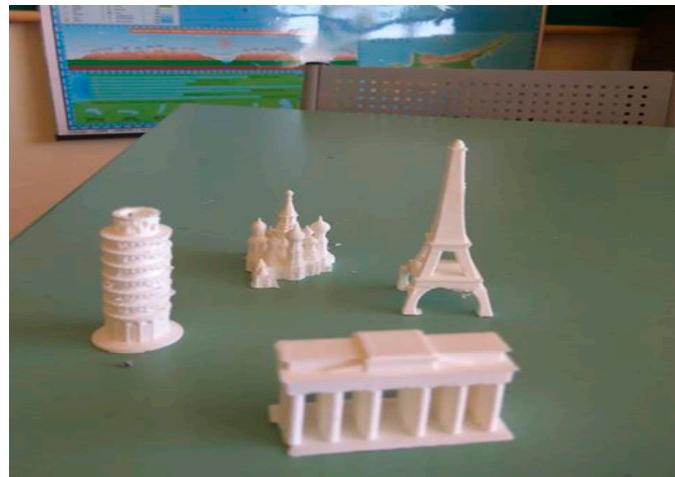


Figure 2. The 3D printed player tokens.

2.1.4. Participants

- (a) Forty-three ($N = 43$), 6th grader students from a private elementary school aged 12 years old, participated at this intervention. Students were divided into two groups:
- experimental group (22 students played the game, which was implemented in the class)
 - control group (21 students attended traditional class)
- (b) Forty-seven ($N = 47$), 6th grader students of a private elementary school, aged 12 years old (a different sample than the main sample) played the digital game at home (due to quarantine) and evaluated it.

2.2. Procedure

2.2.1. Experimental Group

Assisted by their teacher, students chose the monuments to be modeled and then used the Thingiverse website for 3D modeling (Figure 3). All tokens were printed in a 3D printer.

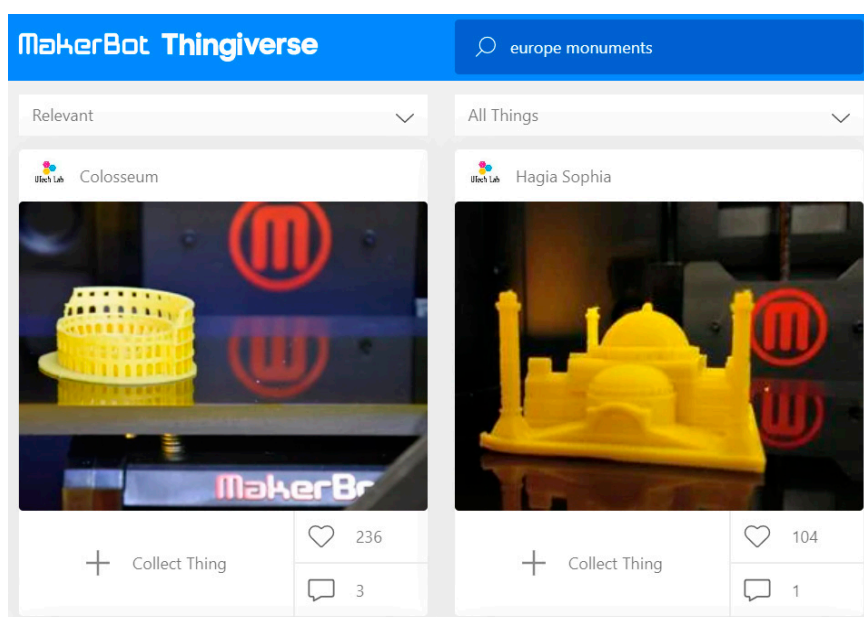


Figure 3. Thingiverse [46] interface to choose and download 3D models.

Following that, students were given a written test, consisting of 5 exercises aligned with the subject’s (European geography) learning goals, as stated in the curriculum. Students were divided into 4 teams and played Geopoly four times. Each game lasted 40 min. In the end, for five minutes all players were discussing the game session, reflecting their strategy.

After this initial educational intervention, students were presented with a post-test assessment and filled out an Intrinsic Motivation Inventory/IMI questionnaire; IMI is a multidimensional measurement device used to assess the subjective experience of participants with respect to a specific activity, providing insight to intrinsic motivation and self-regulation [47] and has been tested for validity using CFA [48] and reliability [49]. Finally, students evaluated the game by answering a questionnaire; this process is summarized in Figure 4.

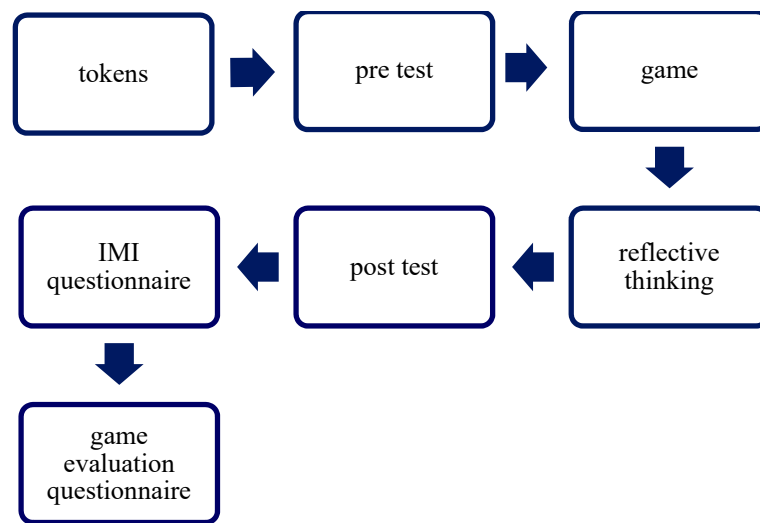


Figure 4. Experimental group’s process.

2.2.2. Control Group

After filling out a pre-test questionnaire, students were taught three chapters of the school textbook, as the curriculum indicates. Finally, all control group students were tested again (post-test) and filled out the IMI and lesson evaluation questionnaires (see Figure 5).

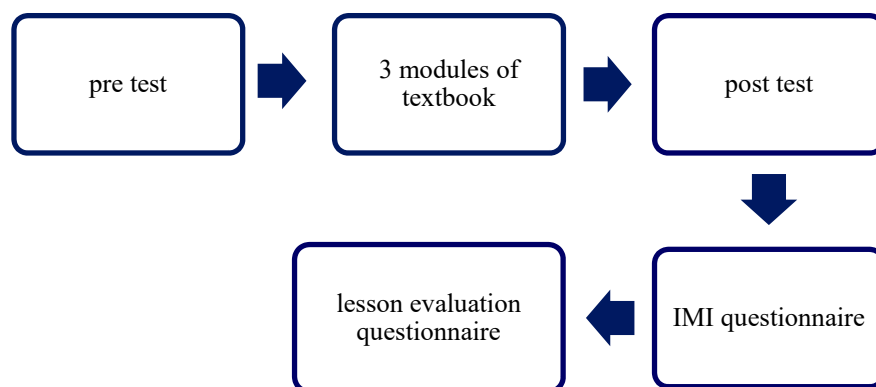


Figure 5. Control group’s process.

2.3. Digital Game

We wanted to further explore Geopoly’s impact on students, so after the completion of the first intervention, we designed a digital version of Geopoly, following the same principles and mechanisms as the board game. Each side of the board represented a European region, countries were grouped by

color and their position represented the perception of relative position. Influenced by current affairs (COVID-19 pandemic), we replaced jail with “quarantine” and taxes with “corona bonds” to make the game more relevant to students’ everyday life. Up to 7 players can play against each other or against the computer. The Digital game upholds mechanisms such as “roll dice”, “buy a property”, “exchange properties”, which promote skills such as strategic and critical thinking.

Students played the game at home, three to four times and evaluated it by answering an online questionnaire.

2.4. Analysis

2.4.1. Research Instruments

Pre-test: Students were tested before the first game session, in a written test, consisting of 5 closed-format exercises, relevant to European geography (ex. Choose the correct answer: One of the most prominent monument of France is (a) Colosseum, (b) Eiffel Tower, (c) Parthenon, (d) Brandenburg’s Gate). Pre-test’s highest score was 100 points.

Post-test: Students were tested after the last game session, in a written test, consisting of 5 closed-format exercises, relevant to European geography (ex. Choose South Europe’s biggest country: (a) Greece, (b) Italy, (c) Portugal, (d) Spain). Post-test’s highest score was 100 points. Both tests’ scores were used to measure students’ academic performance.

Post-experiment questionnaire: A five-point Likert scale questionnaire was given to students, to evaluate their experience, after they played Geopoly (ex. Did you enjoy playing Geopoly? 1. Strongly disagree, 2. Disagree, 3. Neither agree nor disagree, 4. Agree, 5. Strongly agree). We used the Cronbach α metric to test for the reliability of the chosen scale. Results ($\alpha = 0,813$) showed that the scale of the questionnaire is reliable (Table 1).

Table 1. Cronbach’s alpha.

	N	
Valid responses	22	100
Excluded	0	0.0
Total	22	&
Cronbach’s alpha	Cronbach’s alpha based on Standardized Items	N of items
0.805	0.8 car	16

2.4.2. IMI Questionnaire

Intrinsic Motivation Inventory (IMI) is a seven-point Likert scale questionnaire [47], which was used to assess students’ subjective experience. It includes nine questions in total, three for each subscale: Interest/Enjoyment; Pressure/Tension; Perceived competence.

The interest/enjoyment subscale is the self-report measure of intrinsic motivation. Perceived competence is considered to be positive predictor of intrinsic motivation as opposed to pressure/tension subscale, which is considered to be negative predictor of intrinsic motivation (ex. “While I was playing the game I was thinking about how much I enjoyed geography”, scale: 1–7, 1: “not at all true”, 4: “somewhat true”, 7: “very true”). All participants filled out the IMI questionnaire and the data from the two questionnaires were used to measure students’ interest in geography.

2.4.3. Online Post-Experiment Questionnaire

A five-point Likert scale evaluation questionnaire was given to students after they played digital Geopoly to evaluate digital game.

3. Results

3.1. Performance

Overall performance: Results on the dependent variable “performance” (see Table 2) showed that both groups (control and experimental) achieved similar scores in the pre-test (~45/100).

Table 2. 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

In order to check for any statistically significant difference between the scores of the two groups, we performed a parametric *t*-test in order to examine means’ equivalence variance (see Table 3); the value of p ($p = 0.958$) showed that there is no statistically significant difference in the pre-test evaluation scores.

This test was followed by a statistical check on the mean scores, which showed that performance for both groups improved. However, the scores in the experimental group were higher (Table 4). In addition, the *t*-test attested (Table 5) that the game improved students’ performance.

There is a statistically significant difference between the means in the two groups ($p = 0.02 < 0.05$), which confirms our assumption that the game improved student performance.

Finally, an independent sample *t*-test for each group (Table 6 for the experimental group and Table 7 for the control group) showed the impact of the game and conventional lesson on students’ academic performance.

Using Levene’s test, we analyzed pre-test and post-test scores for each group. Both groups’ performance was enhanced but in comparison, experimental group showed greater improvement. Hence, Geopoly did have effect on students’ performance.

Gender difference: We tested for a difference between the mean score across genders (Tables 8 and 9). The significance level in the control group ($p = 0.728 > 0.05$) and the experimental group ($p = 0.574 > 0.05$) verified our null hypothesis that boys’ scores do not vary from girls’. Based on Table 10, Levene’s Test null hypothesis is satisfied for both cases (experimental and control) yielding that the variances are equal. Ergo, the student’s *t*-test can be used to compare the two populations’ mean (assumption for equality of means is satisfied). The *t*-test’s result (Table 10) indicates that the null hypothesis is satisfied hence, the performance of the two groups displays no significant difference.

Table 3. 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	0.294	0.591	0.053	41	0.958	0.32	6.03	-11.86	12.49
Equal variances not assumed			0.053	40.93	0.958	0.32	6.01	-11.83	12.47

Table 4. 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

Table 5. Independent samples test (post-test).

Post-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	1.375	0.248	3.351	41	0.002	17.500	5.223	6.95	28.05
Equal variances not assumed			3.364	40.439	0.002	17.500	5.20	6.99	28.01

Table 6. Independent sample t-test (pre-test–post-test) experimental group.

Experimental Group	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	0.055	0.816	−5.628	42	0.000	−33.181	5.896	−45.08	−21.28
Equal variances not assumed			−5.628	41.44	0.000	−33.181	5.896	−45.08	−21.27

Table 7. Independent sample t-test (pre-test–post-test) control group.

Control Group	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	0.413	0.524	−2.996	40	0.0046	−16.000	5.339	−26.792	−5.207
Equal variances not assumed			−2.996	38.66	0.005	−16.000	5.339	−26.803	−5.196

Table 8. Performance across genders.

		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

Table 9. Performance statistics per gender.

		Experimental Group		Control Group	
	Gender	N	Mean	N	Mean
Def	Girls	10	35.2	8	18.2
	Boys	12	31.5	13	14.6

Table 10. Statistical analysis of student performance.

Control Group	Levene’s Test for Equality of Variances		t-test for Equality of Means		
	F	Sig.	t	df	Sig. (2-Tailed)
Equal variances assumed	1.632	0.217	0.352	19	0.728
Equal variances not assumed			0.398	18.992	0.695
Experimental Group					
Equal variances assumed	0.304	0.588	0.572	20	0.574
Equal variances not assumed			0.556	16.226	0.586

3.2. Interest

We wanted to examine whether Geopoly affected students’ interest in geography. To this end, we used the data from the IMI questionnaire which explores intrinsic motivation and tested for correlation between interest, a positive indicator of intrinsic motivation, and academic performance. Since the variable “interest” was not distributed normally, we used Spearman’s rank-correlation (see Table 11), which indicated a strong positive correlation ($\rho = 0.844$) between the two variables (academic performance and interest).

Table 11. Spearman’s rank correlation.

		Post-Test	Interest (IMI)
Post-test	Correlation coefficient	1.000	0.844
	N	22	22
Interest (IMI)	Correlation coefficient	0.844	1.000
	N	22	22

The scatter plot in Figure 6 shows a monotonic direct relationship between two variables. This correlation signifies that as students’ interest increases, their performance increases as well. Anxiety and perceived competence, subscales of Intrinsic Motivation Inventory were tested but did not show any significant relation to academic performance.

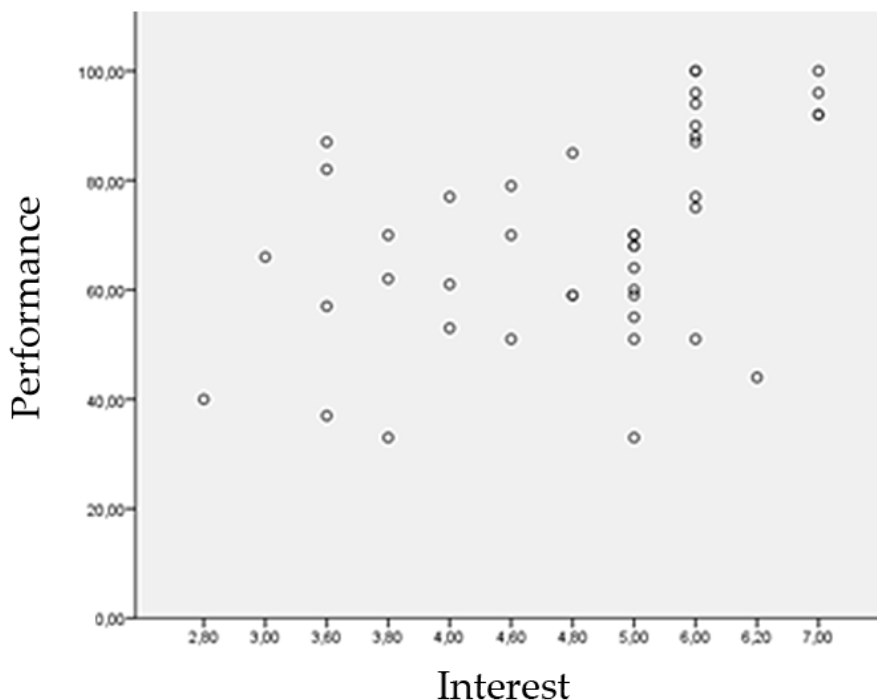


Figure 6. Correlation between interest and performance.

Finally, we explored whether students who played the game showed as much interest in geography as students who attended traditional class. The variable “interest” of experimental group was not normally distributed, so we used the Mann–Whitney U test to compare differences between the two groups. The test resulted in a higher average ranking (30.30) in the experimental group, compared to that of the control group (13.31), meaning that mean rank of interest is higher in the experimental group (results in Table 12).

Table 12. Results from the non-parametric Mann–Whitney U test.

Group	N	Mean Rank
Experimental	22	30.30
Control	21	13.31

As shown in Table 13, significance level ($p = 0 < 0.05$) rejects the null hypothesis for both groups and confirms that the students in the experimental group showed more interest in the subject of geography than those in the control group.

Table 13. Significance level Mann–Whitney’s U test.

	Interest
Mann-Whitney U	48.500
Asymp. Sig. (2-tailed)	0.000

3.2.1. Digital Game

Digital game’s questionnaire results shed further light on how students’ interest and strategic skills are affected by the game. Forty-seven sixth grader students (27 girls and 20 boys) played digital Geopoly. Students rated the game, evaluated their performance and compared the game to traditional method of teaching.

3.2.2. Motivation

At first, we wanted to know if the game had an impact on students’ strategic skills.

As indicated in Figure 7, students believed that their strategy was improved, and all their moves were deliberated. By playing the game they enhanced their strategic skills.

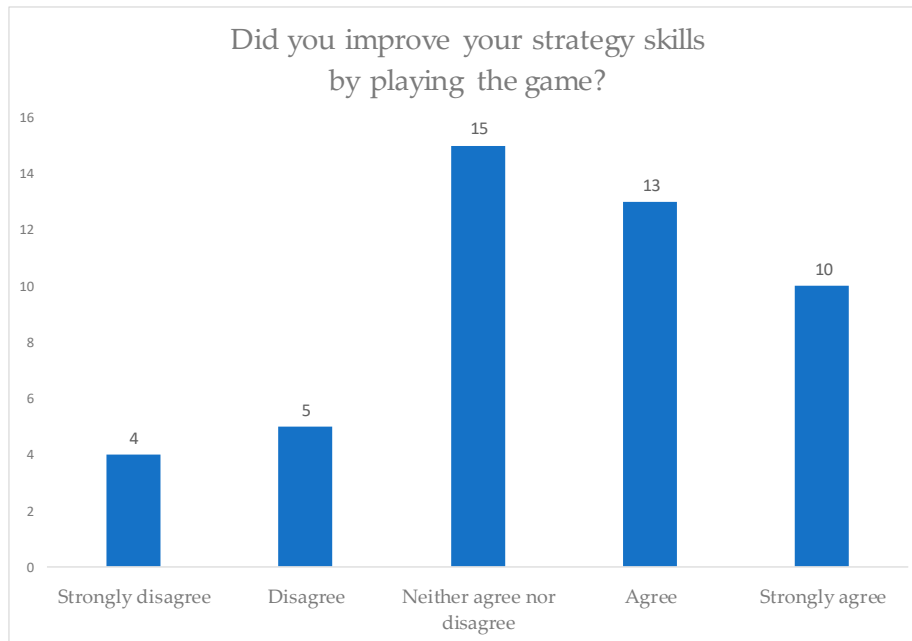


Figure 7. Questionnaire results regarding students’ perception of gameplay strategy improvement.

3.2.3. Interest

Students’ answers (Figures 8–10) revealed that they found digital Geopoly really interesting and that they preferred the digital game to the traditional lesson. They would also like the game to be online and multiplayer, so they could play with their friends.

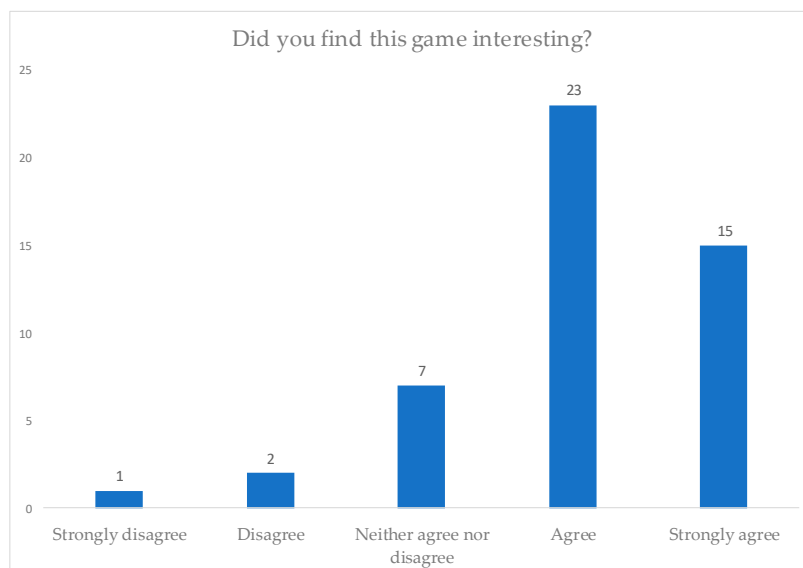


Figure 8. Questionnaire results regarding students’ interest in the game.

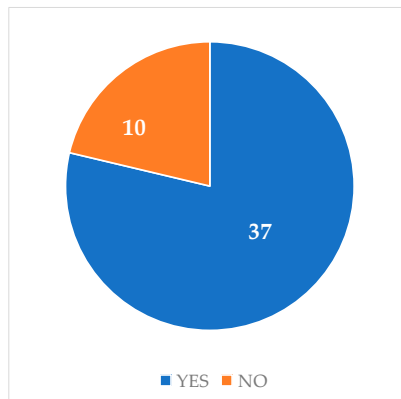


Figure 9. Questionnaire results on replacing the textbook with the game.

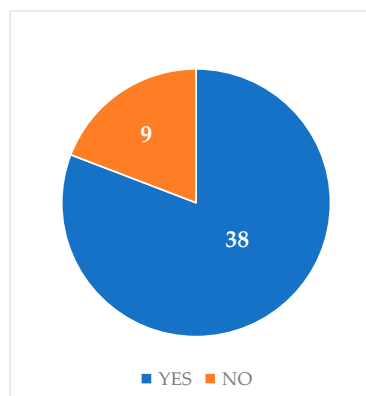


Figure 10. Questionnaire results on a multi-player setup for the game.

3.2.4. Academic Performance

Finally, students evaluated the impact of the game in their academic performance.

Most students believe that they gained more knowledge about Europe by playing the game (Figure 11). They also think that they met, to some extent, the learning goals of the curriculum, i.e., distinguish the four regions in which Europe is divided (Figure 12), obtain knowledge about a large number of European countries, compare their size (Figure 13) and perceive the concept of relative size.

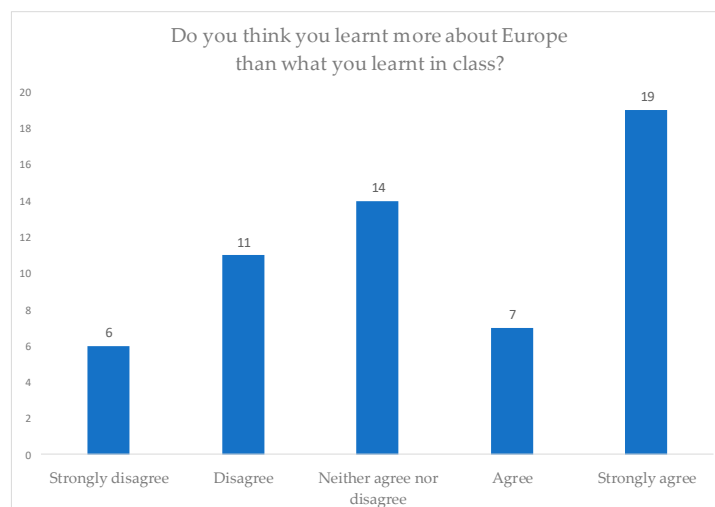


Figure 11. Self-reported comparison between conventional and Game-Based Learning (GBL).

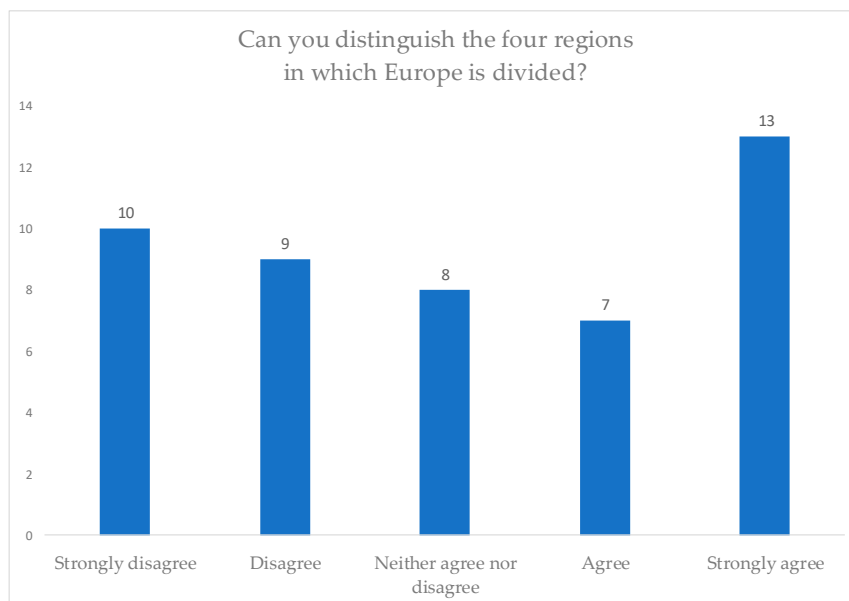


Figure 12. Self-reported perception of academic performance.

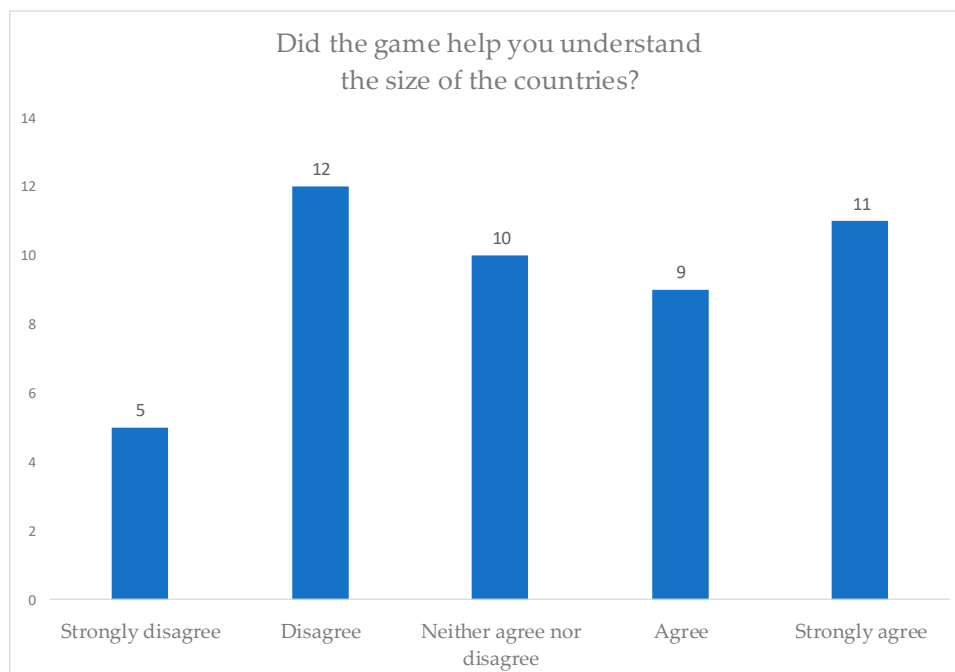


Figure 13. Self-reported effect on learning country size (cf. one of the core mechanics of Monopoly/Geopoly).

4. Discussion

This paper describes the design and implementation of a GBL study, where a board and a digital game that utilize content from Big and open Data were adapted to fit the learning objectives of a geography module. Our main objectives were to educate the students about the relationships contained in big data (ranking, grouping and spatial relations) and compare traditional learning with GBL in terms of motivation, interest and educational effectiveness. Monopoly (and Geopoly, the clone that we created for this work) utilize a grouping mechanic (group colors), a positioning mechanic (positioning countries on the four sides of the board corresponding to their position on the map), and a ranking mechanic (rent price in the original game, size and population in Geopoly); these were the actual mechanics that helped students understand the concepts contained in the data, with respect to

the learning objectives, while the “pay rent” and “purchase property” mechanics were mostly related to the motivation and fun factors, fostering strategic thinking and competition.

The students’ familiarization with Big Data relationships and their academic performance and interest in the game and the course were measured through respective questionnaires. Our analysis revealed that students’ first contact with Big Data and GBL environments, (in physical or digital form) was successful and outmatched the traditional method of teaching. This study confirmed that the learning goals, as stated in the school curriculum, were achieved and students’ academic performance improved by playing Geopoly, which effectively meant that they were able to identify the ranking, grouping and positioning relationships in the data. There has been much interest in gender differences in recent years [50], with significant results in geography-related activities [51] and STEM subjects, such as Mathematics or Physics [52]. However, our evidence suggested that there was no variation in the performance of boys and girls.

Game-based learning environments offer significant potential for increasing motivation and student engagement [53], which is related to their cognitive and emotional involvement [54–57] in the gameplay [20,58]. The digital version of the game kept students engaged and motivated all the way, which was especially difficult given that schools were closed, and strict measures were enforced during the experiment. Students made good use of their spare time at home during quarantine, as the game created a positive learning environment by bringing fun, play and learning together.

More extensive research is proposed to introduce the digital version of the board game in the educational process, so that instructors and learners become more familiar with this learning theory and integrate it in more modules by using different Big Data sets. At the same time, it would be interesting to create a more interactive, online multiplayer version of the game and adapt it so that it can be used in other subjects in which the performance of boys and girls differs greatly [52]. In general, our research emphasizes that if teachers are provided with more and better opportunities to integrate GBL in the teaching practice, this will cultivate 21st century skills [57,59], besides successfully conveying each module’s learning objectives.

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