Education and Information Technologies
https://doi.org/10.1007/s10639-022-11138-w

Computer games and the study of terminology: An application to national accounts

Elias Melchor-Ferrer[1] · Maria Angeles Davia-Rodriguez[2]

Received: 7 March 2022 / Accepted: 25 May 2022

Abstract
This paper introduces a computer application, based on The Alphabet Game, designed to assist students of all disciplines understand the key academic concepts used in their respective fields, with specific application to economics and the study of national accounts. This approach offers a valuable contribution, in view of the difficulties often encountered in presenting key national accounting concepts in a dynamic and appealing manner. Due to the flexibility of the application, it can also be adapted to other fields of knowledge requiring the use of specialized or technical concepts. To assess the game's impact on enhancing learning, students of national accounts in economics were asked to assess their participation by means of an attitudinal survey focusing on motivation, quality of learning, and the effective use of time. The survey was completed by 60 students from two Spanish universities. The overall assessment of the game was strongly correlated with its contribution to the memorization of concepts, usefulness, and enjoy ability. The second evaluation assessed the impact of the game through measurement of its effect on academic performance, with students´ academic records related to the scores from both individual and group gameplay. The assessment was done using a multivariate analysis consisting of a set of semi-logarithmic regression models in which the exam score was the dependent variable and a combination of game results according to the version played (individual, group, or both) were the explanatory variables. All combinations indicated that the individual game is much more strongly related to overall academic performance than the group score. However, to better assess the game, a control group, homogeneous samples, or pre- and post-tests should be used. Finally, to improve the game's impact on learning, it can be used as a compulsory scoring activity, or a badge system could be implemented. Nonetheless, this tool should only be understood as an inextricable part of other assessment and learning activities.

Keywords Gamification · Learning strategies · National accounts learning, study environment

✉ Elias Melchor-Ferrer
emelchor@ugr.es

Extended author information available on the last page of the article

Published online: 27 June 2022

JEL Classification A22 · E01

1 Introduction

In this study we introduce an interactive and motivating, educational computer game which also offers evaluation of student learning. The main benefit derived from the use of instructional technology relates to the form in which it encourages student interaction, and is thus a sound pedagogical tool (Goffe & Sosin, 2005). To facilitate the learning of interdisciplinary concepts, we designed a software version of *The Alphabet Game*, a BBC television quiz popular in the United Kingdom and Spain. The application can easily be adapted by the teacher to enable individual and group play, both at home and in the classroom. Scores generate incentives for improved performance, and provide an attractive, alternative means to encourage learning, with the option of additional reinforcement through image or text files. The rules of gameplay for group and individual modes are outlined with illustrations in Sect. 2.

To gauge the effectiveness of the game, it was incorporated as an activity into two undergraduate economics courses at two Spanish universities. A preliminary survey was conducted after students´ first contact with the game; initial assessments were positive with regard to the formal features and potential utility of the tool, with students indicating that it was enjoyable and interesting, and contributed to the learning process.

Evaluation of the tool for the acquisition of national accounting concepts was conducted through the empirical estimation of the impact of gameplay, scores, and game mode on overall student performance. Results indicated that the game was effective in enhancing student learning, although both game participation and game scores may be correlated to other factors influencing academic performance.

2 Justification and objectives

While true that over recent years the use of educational games for learning has been the focus of much research, there are few well-established theoretical frameworks or a unified discourse on the topic. Arguably, their positive impact is both context and user dependent, with education and learning within crowdsourcing systems representing the most common situations for use. Studies conducted within such contexts indicate that the use of games is mainly positive, with specific reference to increased motivation, enjoyment, and engagement (Hamari et al., 2014). However, positive results depend on clarity in several areas: cognitive strategies employed, the teacher´s game design, and the use of free software to support collaboration in the game effort and experience.

2.1 Memory enhancement as a cognitive strategy in learning

Learning is often represented through the cognitive objectives in Bloom´s Taxonomy, originally theorized in 1956, and republished as Bloom´s Revised Taxonomy (Anderson et al., 2001). To some extent, the revised taxonomy validated the original by mapping six cognitive processes onto the levels of cognition derived from the original (Simkin & Kuechler, 2005). The levels ascend in order, with recall and understanding as lower order skills, and thinking skills in the higher positions. However, as Churches (2009) observes, While the recall of knowledge is the lowest of the taxonomic levels, it is crucial to learning. Remembering does not necessarily have to occur as a distinct activity. For example: the rote learning of facts and figures. Remembering or recall is reinforced by application in higher level activities. As such, remembering is activated when the memory is used to produce definitions, facts or lists, recite or retrieve material; knowledge acquisition through memorization is thus essential to the furthering of knowledge and creation.

Memorization of information is essential for problem solving (Kellogg, 1988), but new input and information must also be integrated with that retrieved from the long-term memory, and in complex cognitive tasks such as language comprehension, spatial processing, mental arithmetic, reasoning and problem solving, the memory is certainly relevant. Students must acquire the learning instruments and attitudes of mind essential to absorb information and extend their knowledge, but it is also vital that they learn specific concepts to extend their background knowledge and conceptual bases. Although the role of teachers can incorporate the transmission of content, when they dominate a class, learners are often the passive recipients of information (Becker & Watts, 2001; George, 2008).

Several studies (Kennedy et al., 2008) have demonstrated that students born after 1980 (digital natives) are enthusiastic users of technology as they were the first to be introduced to connected computers (Gögele et al., 2020) and have a remarkable ability to use electronic devices. The changing nature of higher education must address the challenge digital native students pose (McKee & Tew, 2013) by interconnecting education and technology, and fostering an environment in which students are eager to cooperate with others, share information, collaborate, and innovate (Mufeed & Ahmad, 2018). Teachers can exploit this to connect with them in a meaningful and pedagogically sound manner; students are familiar with computers and expect them to form part of the learning experience and environment in which economics or other disciplines are introduced (Goffe & Sosin, 2005). It is also important to take advantage of other advances in cognitive science and learning support technologies, which are currently having a significant impact on the dynamics of education (Fuggetta, 2012).

Teaching requires the integration of new approaches best suited to students´ abilities and interests, of which digital skills represent a crucial element, and teachers are required to develop their technological repertoire accordingly. Information technologies offer educators the opportunity for collaboration with educational communities and software specialists to design simulations, tools and games for classroom use, which can assist in the delivery of knowledge required by the economists and professionals of the future. As Grosseck (2009) comments, ´It is quite clear that the Universities need to act to ensure that it [*sic*] makes best use of such tools. Still, careful thinking and research are needed in order to find the best way to leverage these emerging tools to boost our teaching and learning activity.´ Such approaches will make it possible to advance from the transmission of content to a more developmental or apprenticeship perspective (Warren, 2001).

One recent strategy for memory enhancement is the development of computational models to improve performance in cognitive tasks (Miyake & Shah, 1999). These models consist of interactive, appealing activities to familiarize both primary and high school students with basic terminology or specialized concepts, learning tools, and ongoing evaluation. Question and answer games offer an attractive alternative for study, as they seek to adapt or modify behaviours; computer games may therefore represent an important vehicle for the acquisition of a range of cognitive tools (Somekh, 2007).

2.2 Design and implementation of computer games in learning

Given the widespread impact of computer games on society, educators are becoming increasingly convinced of their potential as learning tools in which curricular content can be embedded (Tobias & Fletcher, 2012; Begg et al., 2005), and similarly interested in how computers and games can be integrated to enhance teaching and learning.

Gamification is the incorporation of elements of game design and mechanics into non-game contexts to enhance the development of an ability set (Kapp, 2012; Lee & Hammer, 2011; Xu, 2011); with the basic premise of supporting the acquisition of advanced skills and practices, gamification has been applied to such fields as marketing, healthcare, politics, and education. To increase student motivation and engagement (Domínguez et al., 2013), educational games also offer enormous potential, but further research on how to implement social gamification in education and define the characteristics and guidelines of a gamification framework is necessary to fulfil this potential (Simões et al., 2013).

Utilizing a range of mechanics to engage a variety of users in different ways, digital games can support learning throughout primary and secondary school, as well as at university level (Ebner & Holzinger, 2007; Whitton & Hollins, 2008). Despite the pedagogical and motivational benefits of using computer games in education, it has been argued that they are costly, and that they may be inappropriate in some formal educational contexts; practitioners often need be convinced of the potential of such games, and trained to counter their limitations (Whitton, 2012).

Teachers wishing to use digital games may use or modify an existing commercial game, or design and develop an original game. The latter demands an impressive level of expertise in game design, graphics, and interaction design. Twenty years ago, it would have been impossible for an educator with moderate programming knowledge to design a computer game. Today, however, this process is easier than ever and can be easily transferred between teachers. Environments and tools such as Scratch, isEazy, Kodu, GameMaker, Gdevelop, H5P, and Metaverse studio do not involve traditional programming, so even educators without any programming knowledge can make games. Nonetheless, to support learning, Prensky (2008) suggests mini-games of less than an hour as a reasonable alternative to more complex commercial games (Francis, 2006).

Game design involves setting targets, clear rules, and a reward mechanism. Teaching-oriented games should also be appealing (Benjamin, 2010), include rewards offering some ownership of learning, and be sufficiently flexible for individual and group play. For educational games to be enjoyable, user-friendly and flexible, three criteria must be met (Smith-Robbins, 2011): clear targets and success criteria, a transparent process, and an evaluation of the relationship between the outcome and effectiveness of learning, with strategies for improvement.

A reasonable balance between learning and the efficiency and effectiveness of the process must be found, together with the time–cost involved in learning, designing, and implementing a computer program. Although teachers may view the integration of the Internet and software in the classroom positively or negatively, computers and on-line resources are generally very well-received by students, who usually report more positive academic experiences when technology is a component. We concur with Goffe and Sosin (2005) that the most significant question is not whether to use technology, but rather how to use it to contribute to effective learning.

Over the last two decades, the ICT sector has been revolutionized by advances which have profoundly transformed learning (Fuggetta, 2012), and made creative and exploratory pedagogies possible (Heppell, 1993). However, a review of the literature featuring teacher responses to ICT (Mumtaz, 2000) identifies five key areas to consider when integrating ICT in teaching and learning: (1) factors discouraging teachers´ use of technology; (2) schools as organizations; (3) factors encouraging teachers to use technology; (4) the role of the teacher and pedagogical impact of using ICT; and (5) teachers learning to integrate technology into their teaching. While all are important for the successful implementation of ICT, learning requires the active participation of teachers. As such, the addition of educational tools requires negotiation, collaborative decision making, and curriculum adaptation.

Free and open-source software development practices have given rise to a new vision of the construction, deployment, and evolution of complex software systems. There are great benefits to the release and licensing of educational software under the GNU Public License, with the source code freely available for study and code improvement. Teachers, through collaboration and best practice, would be well-placed to design and construct a gamification plug-in for E-learning platforms (Domínguez et al., 2013; Zichermann & Cunningham, 2011). For all these reasons, our computer game can be downloaded for free at the following address http://wpd.ugr.es/~emelchor/Alphabet_game.zip

3 Game design and structure

Gamification process design can be facilitated by software packages such as Excel (Benjamin, 2010), C and Flash programming, dynamic webpages, and more recently, operating systems and software for mobile devices. By virtue of its versatility, popularity, and accessibility, Neobook was selected for the design of the software version of *The Alphabet Game*.

The game requires conceptual dexterity and helps players link terminology with key concepts. Students are shown descriptions corresponding to the letters of the alphabet on a wheel, each of which defines a concept that must be identified; where appropriate, the teacher can enable an image option to offer a clue. In the event of difficulty, the game can be paused, and the problematic letter skipped until the following round, and players continue working through the definitions until the timer sounds.

The design of the game followed Model View Controller architecture, dividing an interactive application into three components: (1) the model, containing core functionality and the database management system; (2) the view, or external schema, providing information to the user by generating events, services, and access to the model; (3) the controllers, which mediate between the view and controllers by coordinating events generated by the model.

The model utilizes dynamic interfaces configured from the contents of the relational database, which constitutes the basis of the game. For adequate game function, a well-designed database is necessary, with the starting points being the situation of interest to the system, and the demands placed on the database. The database stores and connects both the game settings, definitions, and solutions required of the student, so the application was designed with a SQLite (SQLite, 2015) database.

A modular architecture was constructed, with each module responsible for a specific functionality. Various access levels were established to distinguish between user roles (Fig. 1): (1) teacher role (configuration of control data, definition of thesauri, and group game mode); and (2) student role (individual or group play mode). Modules can be limited to the administrator, or shared between all users, regardless of access privileges. To define user access, the administrator must set passwords in the configuration area, with all information stored in the database provided with the program file.

3.1 Features and functions of setup area

Prior to student access, the teacher sets basic game parameters via the password protected configuration area accessed through the main screen. After preliminary adjustments, the teacher can directly access the game, with this area divided into two sections (Fig. 1):

a) Introduction of customizable text (title and subtitle, definitions and help files) (Fig. 2). The definition, name of optional image support file and identifiers for each record are entered. The name of the text or image support file can also be entered and accessed in the event that the player is unable to answer the question. Two user options are provided: individual or full mode. The first proceeds record by record, while the second offers a single table with database fields in columns and records in rows.
b) Configuration of control data (Fig. 2). The administrator can configure: (1) appearance: background colour for correct, incorrect or unanswered letters; (2) access privileges and period for the setup area and game; (3) implementation: the default table for the database, game letters, individual or group mode, and game time; (4) evaluation: sending results, email preferences, maximum score, help icons, and the penalty for incorrect answers (if enabled, and scale).

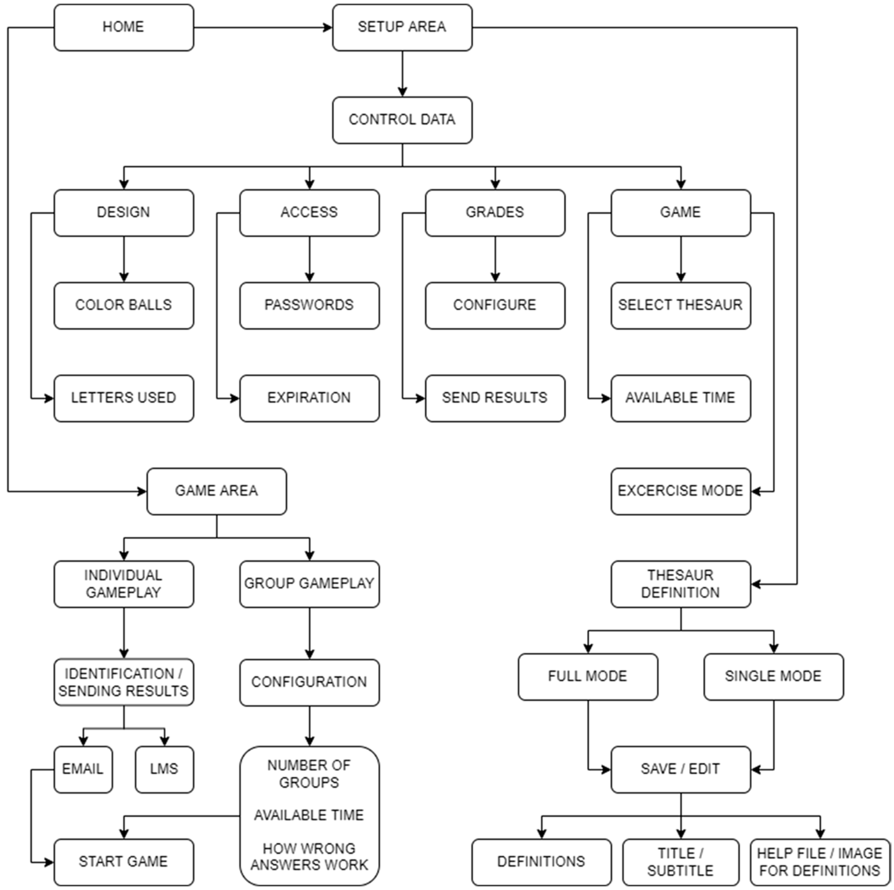

Fig. 1 Structure of the game

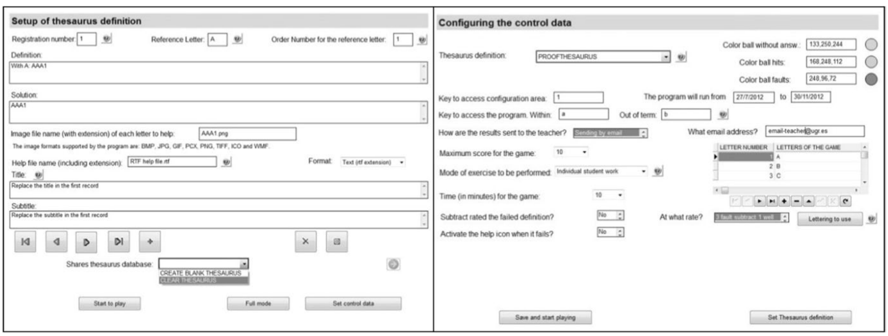

Fig. 2 Screenshot of setup area

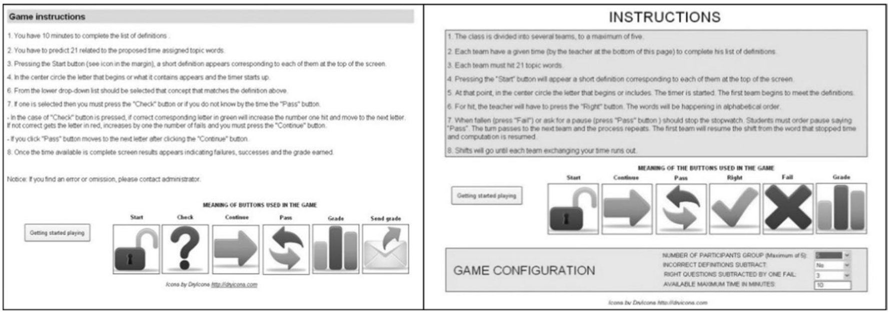

Fig. 3 Instructions for individual and group mode

3.2 Game features for students

Individual and group game modes are available, with specific rules, timing, and scoring for both. The initial game screen offers alternative instructions (Fig. 3) as defined by the mode selected by the teacher prior to play. In individual mode, game options cannot be modified by players, so they are informed of the time available and the meaning of icons. In group mode, icons are explained in the classroom, and the monitor must also specify the number of groups, time available, and penalties for incorrect answers. Once these game specifications are defined, the circle corresponding to the first group appears on the screen. After clicking on the padlock, the definition the group must respond to is displayed and the clock begins to tick. If the group knows the answer, the group spokesperson has to say it and the teacher will mark the answer as correct or incorrect. In the first case, the definitions of the letters will continue to appear on the screen until the group gives the wrong answer or asks to “pass” to the next letter. In any of these last two situations, the clock stops, and two buttons appear: one button to see the results and scores of each group and another help button in which the image or text that the teacher has embedded in the program will appear. Similarly, the players can click on a button at the bottom of the screen to see the number of the group whose turn it is to play. During the game, the teacher is responsible for reviewing the answers and can access all the definitions and show the students their scores. Note that the group version cannot be played remotely.

When used as an evaluation tool, the individual mode score informs the teacher of the baseline level obtained in the first round, and of the effectiveness of the game as indicated by improving results. Duration can be varied to increase or decrease difficulty, which is also useful for evaluation purposes. To play the game individually, students must enter their personal data (name, class, ID number, etc.) after viewing the instructions screen and before the game starts. When the game is over, the students can see their results and send them to the teacher via email. To ensure that the students indicate the real score in the email, they cannot see or modify the content of the email. Benefits of the individual format are that it familiarizes the student with gameplay, the instructions, and the environment, and allows opportunity for private practice.

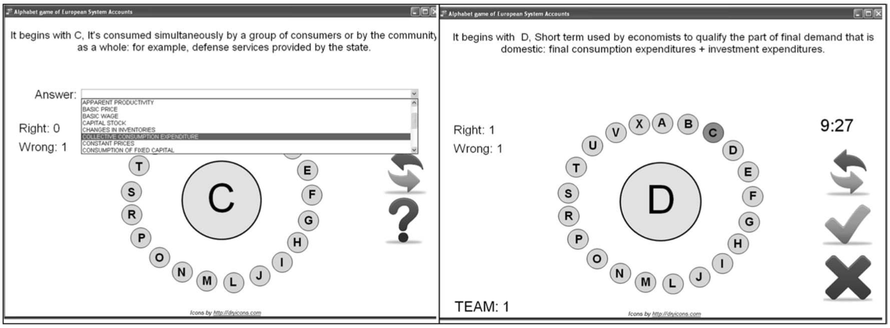

Fig. 4 Individual and group versions

Groups or teams (depending on class size) are required to answer the questions corresponding to the letters of the alphabet chosen for the wheel. Each definition relates to a concept, with all concepts and definitions retrieved from the same database as that of the individual game. Prior to game play, the teacher defines the concepts that either begin with or contain the highlighted letter. Contestants identify the correct concept, or ´pass´ on the letter, at which point turns are taken until the set time has elapsed. If competitors provide all concepts, they are awarded the maximum score.

In the individual game format, one answer is selected from several alternatives on a drop-down menu (Fig. 4). The timer cannot be paused by the student at any stage in the game, and the student is shown the correct answer after their turn has finished. In group mode, the instructor indicates if the answer is correct, and if not, the question is passed to the opposing side (Fig. 4). When a team fails to answer a question correctly, their timer is stopped until their opponents also answer a question incorrectly, at which point the turn passes back to the first contestants. In addition, if defined by the teacher in the setup area, a help icon can offer correct answers in a new screen.

The group format of the game promotes cooperative learning, rarely encountered in university economics courses. Slusser and Erickson (2006) emphasize five characteristics identified in research on collaborative learning most likely to lead to student success: (1) face-to face interaction; (2) interdependence; (3) individual accountability; (4) social skills; and (5) group-processing. Integration of collaborative learning can certainly benefit teachers by offering alternative evaluation strategies; traditionally, instructors have used groups for class discussion, or the completion of projects or presentations, but rarely for quizzes or to process concepts. Cortright et al. (2003) reported that collaboration these kinds of activities not only improved students´ grades, but also their retention of content, indicating that group work can be more effective than an individualistic approach.

The final screen in the game shows the results, right and wrong answers, and any unidentified concepts; this report can be sent by e-mail or via a learning management system to the teacher. This software can be adapted to other disciplines through adjusting the definitions, which was considered in the design stage; all game settings such as scoring and game modes can be defined in the configuration of the game database, thus offering the potential to extend the game's utility to other areas of study.

3.3 Application of The Alphabet Game to main concepts of national accounts in economics

The teaching of economics cannot be viewed merely as the transmission of facts, principles and theories through lecturing, although previous knowledge is necessary to enable the association of prior knowledge with new input and understanding. To that end, the teacher of economics would ideally engage students in learning experiences which activate their existing knowledge and provide them with opportunities to integrate new information (Woldab, 2013).

The use of computers in the teaching of economics is by no means a recent development; computer games were first introduced in the early 1970s (Emery & Enger, 1972). Goffe and Sosin (2005) surveyed the diverse ways in which economics teachers have made use of the Internet, computers, and games. Most of the games investigated seek to teach economic principles, game theory (Bodo, 2002; Dixit, 2005; Lange & Baylor, 2007) and computing simulations at micro and macro levels (Ironside et al., 2004; Pablo-Romero et al., 2012; Pozo-Barajas et al., 2013; Surdam, 2009; Woltjer, 2005), but none of those encountered could be applied to the teaching of national accounts.

National accounting, despite its relevance to economic policy and science, is perceived to be one of the dullest topics in economics (Reich, 2010). It is by means of national accounts statistics that the size, structure, growth, and development of national economies can be measured, but even teachers and researchers tend to devote less attention to this area than to others. National accounting is often taught in macroeconomics at the beginning of degree courses, but following this introduction, authentic macroeconomic figures are not always an area of focus. As a result, key concepts soon come to be seen as lacking in practical value, which discourages teachers and demotivates students. To avoid this situation, greater use should be made of active, student-centred learning methods (Watts & Becker, 2008).

One challenge teachers face lies in communicating national accounting concepts dynamically. While technological advances have opened up new avenues, most examples are rather static and text-dense; many tools are simply electronic versions of books, requiring no cognitive effort to scroll through the text. However, in this case, specific concepts in national accounts, and the relationships between them are addressed in a dynamic and competitive fashion.

To understand national accounts, students are required to master problem-solving skills. As many economic concepts may seem familiar, lecturers are required to present them in a variety of ways for students to able to discriminate between different approaches (Kinsella, 2008), and implement them. (Gremmen & Potters, 1997) examined student achievement when a game-based approach was used to introduce the impact of economic policies on a macroeconomic model; results showed greater student learning in comparison to traditional lecturing.

Memorization is also required to learn key concepts (e.g., the components of GDP affecting national income) which are also used in the estimation and interpretation of macroaggregates (e.g., GDP or national income) crucial to understanding the structure and evolution of national economies. As such, memory development through the application of cognitive strategies is necessary to improve interconnections with existing knowledge. *The Alphabet Game* provides learners with such an approach to memorization by: (a) offering short-term objectives leading to a goal; (b) offering levels of difficulty; (c) providing scores and rewards; and (d) ranking users and progress. The game offers an enjoyable experience in a field traditionally considered rather arid and can be used as a classroom or individual activity, thus aiding both understanding and memorization.

The example pertaining to national accounts places the concepts in letter order, with questions to which the solutions either begin with, or contain, a particular letter. For example, the clues may be: ´Starting with G,´ or ´This includes a D.´ The definition may be ´This is the overall value of all goods and services produced in an economy during a year,´ with GDP as the correct answer.

The following section outlines how the game has been implemented in university courses, and our strategy to evaluate its contribution to student learning.

4 Assessment design and implementation

To determine the effectiveness of the tool, a trial with authentic participants was conducted, with comparison of their results with those of non-players. The game was trialled for two years at The University of Granada and The University of Castilla-La Mancha. In the former, the game was part of the curriculum of ´Instruments for the Study of Spanish and International Economics´, a third semester subject, while in the latter, it was integrated into ´Applied Economic Principles´, studied in the second semester. National accounting is a major curriculum component in both subjects, with a significant proportion of the exam and final assessment focussed on the knowledge and ability to use and interpret key concepts.

All students in both courses were invited to play the game individually over both academic years, with supervision and rules provided by instructors. Students were able to play several rounds to familiarize themselves with the game and given approximately 90 min to play as many rounds as they wished.

Following individual gameplay, students were asked to complete an attitudinal survey to assess the game, make recommendations regarding design, structure and content, and to rate its effectiveness in increasing knowledge and motivation. The game was played by 123 students (75 in Granada and 58 in Castilla-La Mancha) with a survey response rate of 33% in Granada and 60% in Castilla-La Mancha. Due to the anonymity of the survey, the scores could not be linked to academic records. However, students uploaded their scores to the online teaching platform so teachers could monitor development and add the results to their overall assessments. The survey was used to assess the strengths and weaknesses of the game, with a view to improvement, to aid consideration of its pedagogical potential, and to analyse

Table 1 Questionnaire-based survey: Game scores

		Game score (1–10)	
	Shares	*Mean*	*SD*
Knew the dynamics of the game			
No	0.217	6.9	2.5
Only a bit	0.200	7.2	1.8
Yes	0.583	8.5	1.2
Materials employed			
Previous study	0.617	8.1	1.6
Class guides	0.033	8.7	1.0
Handbook	0.033	9.7	0.4
Just logic & the initial letter	0.317	7.2	1.9
Collaboration with other students			
No	0.450	7.4	2.3
Yes (1–2 others)	0.300	8.1	1.2
Yes (3–4 others)	0.250	8.5	0.8
Overall		7.9	1.8

practical issues with computer games in higher education, thus minimizing their potential shortcomings, as reviewed by Whitton (2009).

The team version was played several weeks after the first individual trial, with the teacher assisting, moderating, and recording the scores. As both individual game results and those obtained by teams were recorded, it was possible to link the performance in both trials with overall academic performance, proxied by the final exam mark.

Table 1 shows the results of the questionnaire-based surveys, together with the assessment of game impact on overall subject performance. The self-administered, online questionnaire was identical for both universities, and students were asked to assess their participation in the game, focusing on motivation, quality of the learning, and the effectiveness of the use of their time.

Students were asked to rate their knowledge of the game rules, report their highest individual score, indicate any materials used, and any support they required or offered during gameplay. The final two questions were open-ended and focused on the strengths and weaknesses of the game. Table 1 indicates the results obtained from students at both universities.

The most positive responses related to interest, usefulness, enjoy ability, and game design, with lower scores awarded to the wording of definitions and ease of gameplay. Mid-level scores were given for the game´s impact on memorization and understanding of national accounts. As a result of this variability, the overall evaluation of the game was also mid-level.

Table 1 also shows the piecewise correlations among the assessments made; significant positive correlations can be seen for all items, although the results for game design are somewhat divergent. The overall assessment of the game was strongly correlated with its contribution to the memorization of concepts, usefulness, and enjoy ability. There were lower, but still significant, levels of correlation between the overall game assessment and the extent to which students found the activity interesting, its contribution to conceptual understanding, and game design. Finally, the self-reported score from the individual version was positively correlated with six items, in descending order: contribution to conceptual understanding, ease of gameplay, usefulness, prior familiarity with game rules, contribution to memorization, and enjoy ability. Scores obtained showed no correlation with either students' interest in the game, or their assessment of the definitions, or design. To prevent manipulation and ensure that the students' scores are the same as those reported in the survey, the data were compared with those emailed automatically by the game. Results monitoring is only available in the individual version, while the group version is designed as a teacher-led classroom activity.

Responses to open-ended questions indicated that the most valuable aspect of the game was in making learning enjoyable. However, most respondents considered that there was insufficient time to answer all questions, which were sometimes lengthy or the wording unclear. Many students devoted no time to prior study, and without handbooks or other materials, they required more time to answer. However, experience demonstrates that once familiar with the rules, having played several individual rounds, and with time provided for additional study, these issues were eliminated for the group rounds. Overall, respondents were reasonably satisfied with the game, particularly about the support offered in memorizing concepts effectively and enjoyably.

Records for 208 students in the years 2017/18 and 2018/19 were available, with 168 (80.3%) taking the exam. As the game was not a compulsory activity, 45% of students played individually and 55% in groups, with only 29% having no contact of any kind. Scores for the individual game were ranked: low (<5), intermediate (5–7) and high (>7). As expected, the results for group games were significantly higher than those obtained in individual play, and as a result, the group scores were ranked with alternative values: low (<7), intermediate (7–8.5) and high (>8.5). The results of the multivariate analysis of exam scores are shown in Table 2, in which the final column indicates the relative frequencies of all explanatory variables.

The multivariate analysis consisted of a set of semi-logarithmic regression models in which the dependent variable was the exam score[1] (in logs). Although students were not asked in the exam to define concepts of national accounts encountered in the game, they were required to use them to obtain macro-aggregates; had they been unfamiliar with the concepts, they would have been unable to derive the correct values for the macro-aggregates. The explanatory variables refer to game participation, and individual and group scores. Other control variables were gender, academic year and grouping during the day, none of which were statistically significant.

[1] The semi-logarithmic model facilitates interpretation of the results as the proportional change of the dependent variable produced by a change of one unit in the explanatory variables (as all explanatory variables are dummies, a one-unit change is merely the change from 0 to 1). This interpretation should nevertheless be taken with caution, as it is only valid for small ranges of the dependent variable as explained in Thornton and Inness (1989). Since the values of the dependent variable range from 0.4 (the lowest exam score registered) to 10, this straightforward interpretation can be used with confidence.

Table 2 Semi-logarithmic regression: Exam results accounted for by game participation and game scores

	Individual	Teams	Teams & individual	Type of game	Performance	Mean
Score in individual game (ref: Did not play)						0.548
Low	0.231*		0.243*			0.131
Intermediate	0.470***		0.433***			0.244
High	0.348**		0.313**			0.077
Score in team game (ref: Did not play)						0.446
Low		-0.096	-0.079			0.119
Intermediate		0.143	0.063			0.226
High		0.277**	0.145			0.208
Play individually and/or in groups (ref: Neither)						0.292
Only in groups				0.115		0.256
Only individually				0.448***		0.155
Both individually and in groups				0.435***		0.298
Combined performance (ref: Did not play)						0.292
Low score in both individual and group game					0.273	0.018
Better individual than group score					0.404***	0.190
Better (or equal to) group than individual score					0.280***	0.500
Female	0.128	0.172*	0.121	0.116	0.167*	0.530
Afternoon course	-0.073	-0.009	-0.016	-0.054	-0.077	0.446
Previous course	0.137*	0.063	0.107	0.123	0.087	0.458
Constant	1.184***	1.259***	1.151***	1.132***	1.137***	
Observations	168	168	168	168	168	
R-squared	0.195	0.103	0.205	0.184	0.137	
F	6.487	3.083	4.526	6.058	4.253	

Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Five models were specified, differing according to the combination of game results used as explanatory variables: (1) group score; (2) individual score; (3) combination of both scores; (4) combination of games played; and (5) comparison between the individual and group scores. All combinations indicated that the individual game is much more strongly related to overall academic performance than the group score. In the absence of individual game scores, only the students who obtained high scores as a group obtained a higher mark in their final exam. When both individual and group scores were included in the model, only those who performed well or very well in the individual game attained significantly higher exam scores (30–40% higher than those who did not play the game individually), while scores in the group game decreased in significance. Again, students who only played in groups did not attain better results than those who did not play at all, and only those who played well or very well individually, regardless of their group score, recorded significantly higher exam results. Underlining the importance of individual play, those students who performed better individually than in groups attained a higher mark (around 40% higher than those who did not play at all), while those who performed better or equally in groups than individually only reported an improvement of 28% in their final exam.

Results suggest that *The Alphabet Game* is effective for teaching national accounts, in that there is a positive correlation with students' final academic performance, although only with reference to individual play. Students enjoyed group gameplay and obtained higher scores than previously recorded individually, although perhaps because of the time dedicated to study and practice between the individual and group games, and later group collaboration. However, this raises the question as to whether group play contributed in any way to the learning process. As the ratio between the statistical deviation and the mean in the scores of the team games was lower than in the individual mode, there is actually a lower variance in the results of the group version than in that of the individual version, and hence lower statistical significance of the scores in the group games in the models. Thus, initially weaker students may have benefitted from group-work, but this did not have a significant impact on their overall performance. Nevertheless, we must also acknowledge the low value of the R^2 coefficient, which indicates that there are unobserved features not present in the specification; furthermore, the model, in its current form, has a rather low explanatory power. Previous experiments have shown that indicators of effort and ability are reliable predictors of results, as is successful participation in certain activities.

Although the correlation results indicate that The Alphabet Game has a positive impact on the teaching and learning of national accounts, it would be interesting to use a control group, homogeneous samples, and pre- and post-tests, among others, to better determine the effectiveness of the game experiments. As regards the attitudinal survey, it could be extended to include additional factors that contributed to the exam results of students who played the individual version of the game. Factors such as study time, learning ability, number of lectures attended, and prior knowledge should also be considered. All these issues, if implemented, would provide additional data to again analyse the results and reassess the game's impact on learning.

5 Conclusions

This paper introduces a computer application designed to facilitate the study of terminology or specialized concepts in any subject, promote students´ ability to link ideas, and improve mental agility. While implemented in the teaching of national accounts in undergraduate economics courses, given the format and flexibility of the tool, it could easily be adapted to fields involving numerous concepts or specialized jargon. Appropriate areas might be financial markets (instruments and institutions) or the history of economic thought, where students could, for example, connect aspects of the contribution of authors to their names. This application could certainly be extended to other areas of economics and social sciences; indeed, different versions of the game have been used in such disciplines as pharmacology. There is even the potential for application in schools for the study of the mother tongue or a second language (Brawerman et al., 2013; Pawar et al., 2006), and we have already introduced an image help option to support learning in non-university studies.

Research trials conducted with university students show it to be an effective tool. Students enjoyed playing it, and retained more national accounting concepts than those who did not play; some concepts were learned during the game, meaning students were then better equipped to apply them in practical exercises involving connections between macroeconomic aggregates. Therefore, there is convincing evidence of the effectiveness of the game in improving learning, as well as the value of other benefits offered: enhanced motivation, and increased class participation. Nevertheless, the evaluation of the tool could be improved by randomizing participation in the game in the initial selection and grouping of students. Dividing the focus would allow for a better comparison across game modes by not allowing sequential play; namely, first individual, and then group play. To counter this, one group would only play individually and the other would play only in grouped mode. However, from a pedagogical perspective, playing both versions seem sensible: the individual version supports personal study, and group play may be used as a classroom assessment activity, and of course, for collaboration and enjoyment. Alternatively, the order of the games could be reversed, being played first in groups as a classroom activity, and reserving the individual game for use as an evaluation tool.

Evaluation of the software gave rise to further ideas for improvement, such as the expansion of initial instructions through a video or web-based tutorial to improve understanding of the rules prior to play, or by simplifying the wording of definitions found to present the greatest difficulty. This would increase the students' dexterity during the game and enable them to finish more quickly. Additional time could be allocated to initial attempts, and progressively reduced in successive rounds. The game could be published in different formats to allow access to a wider range of devices and operating systems. Finally, running the software in a web browser would overcome several potential obstacles, such as screen resolution and the inclusion of executable antivirus and firewall files.

The construction of tailor-made applications for virtual or gamified teaching is of increasing importance for a variety of educators. The complexity and variety of learning systems and software make it necessary to build interdisciplinary teams to share knowledge and implement developments in teaching methodology; as such, *The Alphabet Game* is available, in open access, in English. Linking a network of lecturers would be a strong strategy to improve not only the tool, but also professional subject knowledge and teaching strategies for those subjects. A network of educators in national accounting or other disciplines could be supported by connecting the game to a web-hosted database which all could access, with online definitions and solutions modified as and when needed, thus offering both reciprocity and collaboration. It would be very gratifying if this game thus inspired teachers in other fields of study who share our teaching aims.

Acknowledgements The authors are thankful for all students and colleagues that provided learning experience to make this research possible. In addition, the authors thank the anonymous reviewers for their helpful and constructive comments and suggestions.

Authors' contributions Elias Melchor-Ferrer: Sects. 1 and 2. Design of the game. Maria Angeles Davia-Rodriguez: Sect. 3 (design of survey and statistical analysis of results). All authors read and approved the final manuscript.

Funding Funding for open access charge: Universidad de Granada / CBUA

Data availability Executable file, additional files and instructions are available at http://wpd.ugr.es/~emelchor/Alphabet_game.zip

Declarations

Conflict of interest The authors don't have any conflict of interest.

References

Anderson, L. W., Krathwohl, D. R., & Bloom, B. S. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Longman.

Becker, W.E. & Watts, M. (2001). Teaching economics at the start of the 21st century: Still chalk-and-talk. *American Economic Review* 446–451.

Begg, M., Dewhurst, D. & Macleod, H. (2005). Game-informed learning: Applying computer game processes to higher education. *Innovate*, *6*(1). Available at http://www.innovateonline.info/index.php?view=articleandid=176.

Benjamin, T. (2010). eGames: Is imagination the forgotten ingredient? *Computers in Human Behavior, 3*(26), 296–301.

Bodo, P. (2002). In-class simulations of the iterated prisoner's dilemma game. *The Journal of Economic Education, 3*(33), 207–216.

Brawerman, A., Bortoloti, C., Guimarães, L.B., Granato, L. C., Aroldi, M. D. & de Souza, V. M. (2013). *ABC Game-Educating Through Mobile Devices, International Conference on Interactive Computer aided Blended Learning*, Itacorubí (Brazil).

Churches, A.. (2009). Taxonomía de Bloom para la era digital, 10/22/2016, http://www.eduteka.org/TaxonomiaBloomDigital.php.

Cortright, R. N., Collins, H. L., Rodenbaugh, D. W., & DiCarlo, S. E. (2003). Student Retention of Course Content is improved by Collaborative-Group Testing. *Advanced Physiological Education, 27*(3), 102–108.

Dixit, A. (2005). Restoring fun to game theory. *The Journal of Economic Education, 3*(36), 205–219.

Domínguez, A., Saenz-de-Navarrete, J., De-Marcos, L., Fernández-Sanz, L., Pagés, C., & Martínez-Herráiz, J. (2013). Gamifying learning experiences: Practical implications and outcomes. *Computers & Education, 63*, 380–392.

Ebner, M., & Holzinger, A. (2007). Successful implementation of user-centered game-based learning in higher education: An example from civil engineering. *Computers & Education, 3*(49), 873–890.

Emery, E. D., & Enger, T. P. (1972). Computer Gaming and Learning in an Introductory Economics Course. *Journal of Economic Education, 2*(3), 77–85.

Francis, R. (2006). *Towards a theory of a games-based pedagogy, Innovating e-learning conference 2006*: Transforming Learning Experiences.

Fuggetta, A. (2012). 3 1 Challenges for the future of universities. *Journal of Systems and Software, 10*(85), 2417–2424.

George, M. F. (2008). On the teaching of financial economics: A pedagogic note. *The Journal of Investing, 3*(17), 105–110.

Goffe, W. L., & Sosin, K. (2005). Teaching with technology: May you live in interesting times. *The Journal of Economic Education, 3*(36), 278–291.

Gögele, S., Schweiger, G., & Kletzenbauer, P. (2020). The Impact of Digital Natives on Blended Learning Scenarios. *International Journal of Innovation, Management and Technology*, *11*(5).

Gremmen, H., & Potters, J. (1997). Assessing the efficacy of gaming in economic education. *The Journal of Economic Education, 4*(28), 291–303.

Grosseck, G. (2009). To use or not to use web 2.0 in higher education? *Procedia-Social and Behavioral Sciences, 1*(1), 478–482.

Hamari, J., Koivisto, J. & Sarsa, H. (2014). Does Gamification Work?—A Literature Review of Empirical Studies on Gamification, Proceedings of the 47th Hawaii International Conference on System Sciences. *HICSS*.

Heppell, S. (1993). Teacher Education, Learning and the Information Generation: The progression and evolution of educational computing against a background of change. *Journal of Information Technology for Teacher Education, 2*(2), 229–237.

Ironside, B., Joerding, W., & Kuzyk, P. (2004). Double-auction market simulation software for very large classes. *The Journal of Economic Education, 3*(35), 284–289.

Kapp, K. M. (2012). *The gamification of learning and instruction: Game-based methods and strategies for training and education*. John Wiley & Sons.

Kellogg, R. T. (1988). Attentional overload and writing performance: Effects of rough draft and outline strategies. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 2*(14), 355.

Kennedy, G. E., Judd, T. S., Churchward, A., Gray, K., & Krause, K.-L. (2008). First year students' experiences with technology: Are they really digital natives? *Australasian Journal of Educational Technology, 24*(1), 108–122.

Kinsella, S. (2008). *Computable and Experimental Economics at the University of Limerick*.

Lange, C., & Baylor, A. L. (2007). Teaching the Repeated Prisoner's Dilemma With a Computerized Tournament. *The Journal of Economic Education, 4*(38), 407–418.

Lee, J. J., & Hammer, J. (2011). Gamification in education: What, how, why bother? *Academic Exchange Quarterly, 2*(15), 146.

McKee, C. W., & Tew, W. M. (2013). Setting the stage for teaching and learning in American higher education: Making the case for faculty development. *New Directions for Teaching and Learning, 2013*(133), 3–14.

Miyake, A. & Shah, P. (1999). *Models of working memory: Mechanisms of active maintenance and executive control*. Cambridge University Press.

Mufeed, G., & Ahmad, R. (2018). Virtual classroom: The future of digital generation. *Researchers' Guild, 1*(2), 19–19.

Mumtaz, S. (2000). Factors affecting teachers' use of information and communications technology: A review of the literature. *Journal of Information Technology for Teacher Education, 3*(9), 319–342.

Pablo-Romero, M.d.P., Pozo-Barajas, R. & de la Palma Gómez-Calero, M. (2012). Evaluation of Teaching the IS-LM Model through a Simulation Program. *Journal of Educational Technology & Society*, *4*(15), 193–204.

Pawar, U.S., Pal, J. & Toyama, K. (2006). Multiple mice for computers in education in developing countries, Information and Communication Technologies and Development, 2006. ICTD'06. *International Conference*.

Pozo-Barajas, R., Pablo-Romero, M.d.P. & Caballero, R. (2013). Evaluating a computer-based simulator program to teach the principles of macroeconomic equilibria. *Computers & Education*, (69), 71–84.

Prensky, M. (2008). Students as designers and creators of educational computer games: Who else? *British Journal of Educational Technology, 6*(39), 1004–1019.

Reich, U. (2010). The National Accounts as a Tool for Analysis and Policy: In View of History. *Economic Theory and Data Compilation Issues. Economic Systems Research*, *3*(22), 301–303.

Scacchi, W. (2004). Free and open-source development practices in the game community. *Software, IEEE, 1*(21), 59–66.

Simkin, M. G., & Kuechler, W. L. (2005). Multiple-Choice Tests and Student Understanding: What Is the Connection? *Decision Sciences Journal of Innovative Education, 1*(3), 73–98.

Simões, J., Redondo, R. D., & Vilas, A. F. (2013). A social gamification framework for a K-6 learning platform. *Computers in Human Behavior, 2*(29), 345–353.

Slusser, S. R., & Erickson, R. J. (2006). Group quizzes: An extension of the collaborative learning process. *Teaching Sociology, 34*(3), 249–262.

Smith-Robbins, S. (2011). This game sucks": How to improve the gamification of education. *EDUCAUSE Review, 1*(46), 58–59.

Somekh, B. (2007). *Pedagogy and learning with ICT: Researching the art of innovation*. Routledge.

SQLite. (2015). SQLite website, 10/29/2015, http://www.sqlite.org/.

Surdam, D. G. (2009). A sports franchise simulation game. *The Journal of Economic Education, 2*(40), 138–149.

Thornton, R. J., & Innes, J. T. (1989). Interpreting semilogarithmic regression coefficients in labor research. *Journal of Labor Research, 4*(10), 443–447.

Tobias, S. & Fletcher, D. (2012). Learning from computer games: A research review. In S. Wannemacker, S. Vandercruysse & G. Clarebout's, (Eds.), *Serious Games: The Challenge* (pp. 6–17). Berlin / Heidelberg, Germany: Springer.

Warren, D. V. (2001). *Design and development of simulation/game software: Implications for higher education*. University of British Columbia.

Watts, M., & Becker, W. E. (2008). A little more than chalk and talk: Results from a third national survey of teaching methods in undergraduate economics courses. *The Journal of Economic Education, 3*(39), 273–286.

Whitton, N. (2012). The place of game-based learning in an age of austerity. *Electronic Journal of E-Learning, 2*(10), 249–256.

Whitton, N., & Hollins, P. (2008). Collaborative virtual gaming worlds in higher education. *Research in Learning Technology, 3*(16), 221–229.

Whitton, N. (2009). Learning and teaching with computer games in higher education. In T. Con-nolly, M. Stansfield & L. and Boyle's, (Eds.) *Games-based learning advancements for multi-sensory human computer interfaces: techniques and effective practices* (pp. 18–33). Hershey, PA: Information Science Reference.

Woldab, Z. E. (2013). Constructivist didactics in teaching economics: A shift in paradigm to be exemplary teacher. *Academic Journal of Interdisciplinary Studies, 1*(2), 197.

Woltjer, G. B. (2005). Decisions and macroeconomics: Development and implementation of a simulation game. *The Journal of Economic Education, 2*(36), 139–144.

Xu, Y. (2011). Literature review on web application gamification and analytics. *Collaborative Software Development Lab Technical Report 11–05*.

Zichermann, G. & Cunningham, C. (2011). *Gamification by design: Implementing game mechanics in web and mobile apps*. O'Reilly Media, Inc.

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Authors and Affiliations

Elias Melchor-Ferrer[1] · Maria Angeles Davia-Rodriguez[2]

Maria Angeles Davia-Rodriguez
mangeles.davia@uclm.es

[1] Faculty of Economics, University of Granada, Campus de Cartuja, s/n. E-18071, Granada, Spain

[2] Faculty of Economics, University of Castilla - La Mancha, Plaza de la Universidad, 1, E-02071, Albacete, Spain