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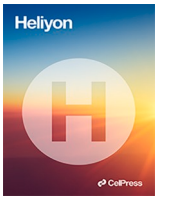

Research article

Serious games to assess students

Hedia Mhiri Sellami

Smart Lab, Institut Supérieur de Gestion de Gestion de Tunis, Université de Tunis, Tunisia

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ABSTRACT

This paper describes experiments where students were assessed using the Serious Games (SGs) they created. The first experiment is with students attending our "Business Games" module for the master's degree in "Innovation" at the Tunis Engineering School. The second experiment involved students enrolled in our "Introduction to Data Science" module of the master's degree in "Data Sciences" at the High Institute of Management of Tunis. We requested each section's students to design a game related to the covered module. Through innovative assessment practices, we hope to motivate students. We aimed to confirm that creating games reinforced students' mastery of the module content. At the end of the semester, students presented their games, and some of them are described here. The results of the questionnaire filled out by the students at the end of these experiments revealed that, despite their different profiles, they appreciated these experiments and their influence on mastering the modules' contents. This article introduces the SG and its use in assessment. It also discusses the importance of creating serious games by the learner and how it affects learning. Even though some students mentioned that creating their games took more time than studying for a traditional exam, they believed the experiment as a whole was positive and enjoyed the innovation. Therefore, to construct the game, students reviewed the content of the module more than once. Additionally, students asked for the experiment to continue and expand to additional modules the following year.

1. Introduction

A Serious game (SG) is an educational application that combines serious aspects of teaching, learning, communication, or even information with the fun aspects of video games [1–3]. Education is significantly affected by the use of SGs because they meet the profile of current students and contribute to the improvement of education [1,2]. This article addresses the creation of serious games by learners and their impact on learning. We tested this on our students, thus, at the start of the 2022–2032 academic year, we asked them to present the content of our modules in the form of games. Their achievements were used to assess them in these modules. Our main goals in carrying out these experiments were to motivate students and help them better master the different chapters. The experiment was carried out with two groups of twenty students with different profiles. These students were enrolled in two different master's degrees at two establishments of the Tunisian University. This article begins by introducing the concept of SG and its use in assessment. The contribution of the creation of SG to the reinforcement of learning is also addressed supported by examples. The environments of our two experiments are then presented as well as some games made by the students. The results of the questionnaire, filled out by students at the end of the experiments, are introduced. They confirm the positive impact of the creation of SG on student learning, despite the diversity of their profiles and the reluctance of some of them. To repeat this experiment or extend it to other

E-mail address: Hedia.mhiri@isg.rnu.tn.

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modules, some recommendations are mentioned. These recommendations come from our management of these experiments as well as student responses.

2. Game development and learning assessment

Numerous studies have demonstrated the effectiveness of the game, whether it is a board game or a video game, especially when it is well designed, as it can promote learning while engaging players [4,5]. Moreover, education is among the most important areas of application of games, particularly SGs. Their potential to meet current needs for educational improvement is well recognized [1,6,7]. Consequently, playing video games has been linked to several perceptual, cognitive, and motivational impacts and outcomes [8,9]. SG can also be viewed as a tool that aids instructors in motivating students and achieving learning goals [8,10]. SGs are also used to assess students, and the majority of these experiments include giving learners a SG before attempting to determine its impact on their performance. This largely concentrated on games created to teach students to play with academic material and skills [5,11]. In addition to the fact that playing games can improve systems thinking literacy, making or creating games affects system fluency instruction, and some researchers focus on the learning benefits when students develop games related to courses [12,13]. Kafai [14] also highlighted how important it is for students to develop their games as a means of learning. According to Farber [15], constructionist gaming offers an opportunity to combine game-based learning with project-based learning. Although studies have generally focused on teaching coding and academic material through game-making, Kafai [14], studied several factors, based on constructionist theory, that encourage producing games for learning by students. According to Kafai [14], this is the difference between playing video games for enjoyment and doing so to learn. By merging academic subject knowledge from many modules, including computer science, software design concepts, and the arts, students create games that are primarily intended for their peers, rather than their instructors. By developing a game (or, at a more detailed level, its techniques, algorithms, and data structures), one might impart personal knowledge to others. The personal dimension of learning through game production concerns the knowledge appropriation and transformation that takes place during the game creation process, and this corresponds with one of our goals [14]. In addition to programming, the benefits for students when creating their SGs include learning other academic disciplines, problem-solving approaches, and other academic skills [16]. Moreover, social benefit concerns the various forms of teamwork that go into making SGs such as sharing and trading designs or working together on the design [17]. Vos [18] also indicated that the activities related to digital game production have a positive effect on the culture of engagement. As a result, constructionist gaming concentrates on teaching the academic areas covered in the curriculum, such as language arts, science, and mathematics [11]. Vos [18] has also confirmed the benefits of creating games by students when describing the research experiment from four elementary schools in The Netherlands with more than two hundred students. One group of students constructed their memory 'drag and drop' game. In the other group, students played an existing 'drag and drop' memory game. The results confirmed that constructing a game is a better way to enhance student motivation and deep learning than playing an existing game. Indeed, students who created a game demonstrated significantly deeper engagement in their learning and strategy use, which involved system analysis, decision-making, and troubleshooting. Another study compared two summer camp groups, and also discovered that the group that produced games showed noticeable improvements in problem-solving [19]. In this summer camp, twenty students (experimental group) used Microsoft Kodu to acquire problem-solving strategies, while and the twenty-four others (control group) simply practiced these strategies by playing games that other people had already created in Kodu. This experiment's report mentioned that students who created their video games significantly outperformed the other students on the validated assessment known as the Program for International Student Assessment [19]. Other education researchers interested in games as learning environments have also become aware of these meta-dimensions of learning in game production [15]. Thus, being convinced by the positive impacts of creating games, we experimented with using them for student assessment. Therefore, we asked our students to present the content of our module through a game. By doing this we aim for innovation and student motivation while helping them to master these modules.

3. Methodology

We conducted experiments with two groups of students during the first semester of the 2022–2023 academic year. The initial experiment involved 20 students, the majority of them were engineers and were enrolled in the master's program "Innovation" at the Tunis Engineering School (Ecole Nationale d'Ingénieur de Tunis: ENIT). These students attended our "Business Games" module that we taught in 10 sessions of 3 h each. In the second group, students were enrolled in the master's program "Data Sciences" at the High Institute of Management of Tunis (Institut Supérieur de Gestion de Tunis: ISG), and our module was "Introduction to Data Science". The "Business Games" module introduced essentially various types of business games and how they are used in companies to foster decision-making abilities or model management procedures. This module was completed online because of an issue with the school's Internet. In the module's first session, we instructed the students to begin designing their games about problems in their line of work. The students were also informed that their assessment would be based on their game performance and on the associated report they have to upload on the university plate form. To create these games, we requested that the Scratch platform be used. Given that these engineering students are not computer scientists, we chose this environment because it is one of the most user-friendly and one of the most suggested programming environments for beginners [20]. Thus, half of the first 6 sessions were dedicated to introducing Scratch. At the beginning of the semester, we listed the games' evaluation criteria, which included creativity and consideration of the module's chapters. For instance, proposals that included only quizzes received lower evaluations than those that included both a situation in the workplace and immersion in the theme. For the last online session, we invited a colleague, who is a member of the committee of this master, to attend the presentation of the games. Through this invitation, we also targeted his awareness of the importance of SGs in

assessment and entrepreneurship. Indeed, this colleague teaches entrepreneurship at ENIT and was responsible for the entrepreneurship center at this high school.

Our second experiment involved 20 students who signed up for our "Introduction to Data Science" module of the master's degree in "Data Sciences" at ISG. In this module, we introduced the information systems in companies, data mining, big data, data visualization, etc. This module is an introduction to the other modules of this master's degree, so its 20 h were completed during the first week of the academic year. Thus, 4-h classroom mornings were dedicated to this course for 5 successive days. At the last session, we requested students to deliver, after one month, the module's material in the form of a play, song, movie, or game they made. Only seven students chose the game version, while the bulk chose the theatre form as we did last year. For the creation of the games, we did not impose an environment because these IT students are proficient in several programming languages. Nearly all of them had a Licenced diploma in computer science. The assessment criteria were comparable to those described previously. The students were also required to upload, on the university plate form, their reports relevant to their game.

4. Results and discussion

The students of the master's degree "Innovation" presented their games online, while the other students presented them in the classroom. We describe some examples of games associated to the module "Introduction to Data Science". The hangman's game, as shown in Fig. 1, is the first game. The player must choose from a list of characters that represent ideas introduced in our module. For example, the student had to select the right characters to write the word "Hadoop", otherwise he will fail and his score will be zero, and he should try again.

The second game is illustrated in Fig. 2. In the game scenario, a list of definitions, introduced in our module, is displayed on the right side of the screen. , and the player must enter the notion that each term refers to on the left side of the screen. The definition of each correct response is blocked and its appearance changes by becoming barred. To correspond with the chapters of each module, the game offers a variety of crosswords. Fig. 2 represents information relevant to the first chapter.

The third game is a board game with the name "Datasciencopoly" because it was primarily influenced by the "Monopoly" game. The board and its converted examples are shown in Fig. 3. Various game boxes correspond to different course ideas. After rolling the dice, the player has to move the piece to the corresponding space to uncover a question relevant to the course content. A reward or penalty may be given to the player, depending on his response.

After presenting their accomplishments, the students from the two groups expressed their appreciation for the experiment. To obtain their comments, we invited them to complete the questionnaire. Their answers were anonymous as we sent the questionnaire via their email group, and we did not ask for the address. Students were free to respond or not. This did not require authorization. The questions asked about the construction of the game, basic information about students, and how well players understood the material in the module. Thirteen answers (65 % of the students) came from the engineering group; the other answers were from all of the seven students who created games from the second group (35 %). To obtain additional responses, we polled many students, but it appears that after the exam was completed, they lost interest in the module.

The answers to some questions posed to the two student groups are presented in Table 1.

The majority of students in ENIT Group 1 are engineers working in different fields. ISG students in group 2 are mostly computer scientists with a Bachelor's degree and who are not yet working in a profession. Despite this disparity in profiles, their responses to the

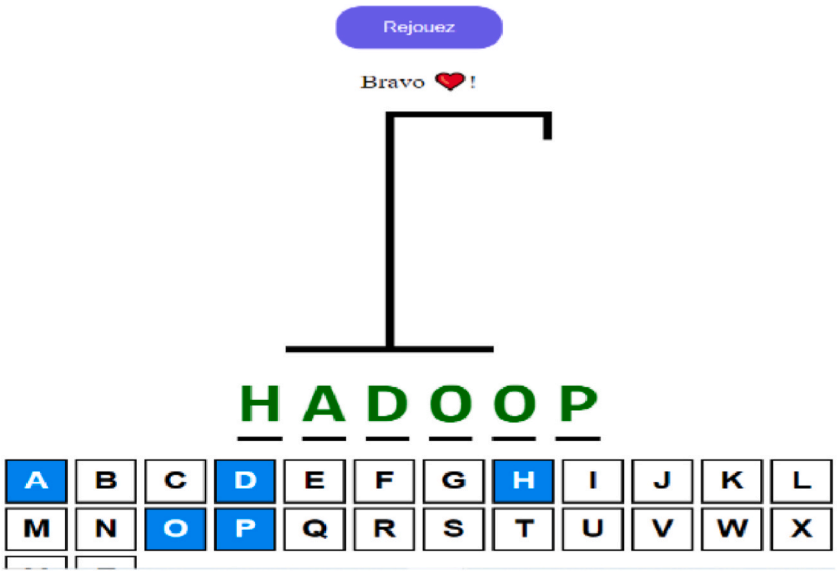

Fig. 1. The first digital game: Hangman.

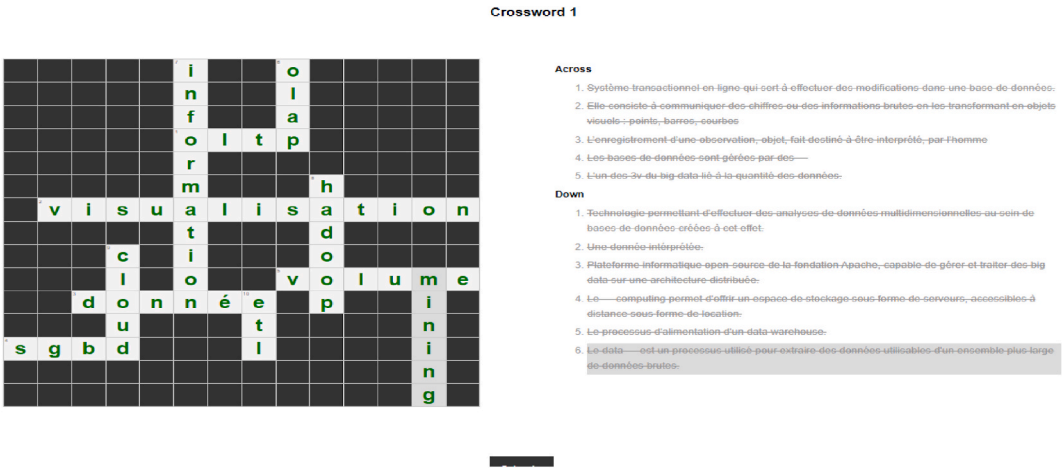

Fig. 2. The second digital game: Crossword.

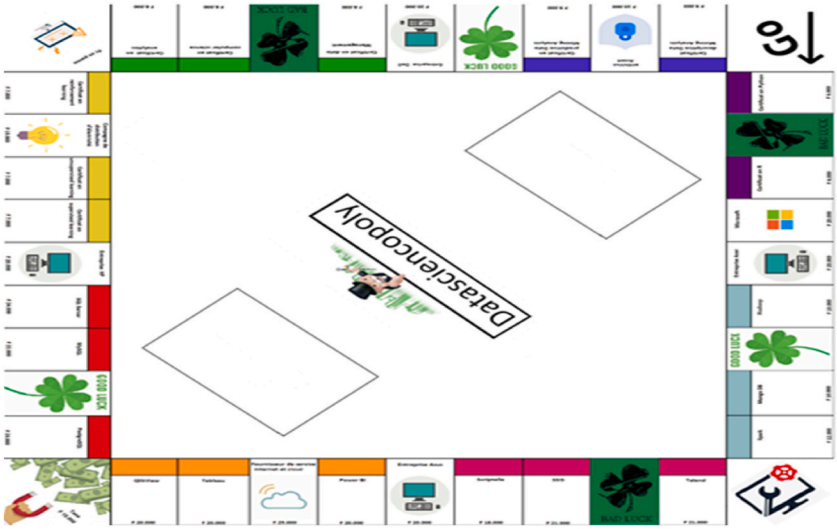

Fig. 3. Board game "Datasciencopoly."

Table 1
Common questions for the two groups.

Question	Master Innovation	Master Data Science
Age	44 and 25; average = 32	21 and 27; average = 23
Diploma	78 % of them have an engineering diploma	100 % of them have a licensed diploma
they revised the course material to create the game	78 % of them	100 % of them
appreciated the proposal to make games for the assessment	87 % of them	100 % of them
they felt that they mastered the different chapters better than with the classic method of revision	78 % of them	100 % of them
prefer to continue with the proposal of games for the future	100 % of them	100 % of them
it took more time than the revision for a classical exam	30 % of them	57 % of them
students propose to use the game with the other modules too	100 % of them	85 % of them
students mentioned that the proposal of making a game motivated them at the beginning of the semester	60 % of them	70 % of them
students mentioned that the game creation process led them to revise course content several times.	87 % of them	85 % of them

questionnaires are very similar.

Indeed, the students supported the idea that making games helped them further their understanding of the module's material and compelled them to better learn it. Thus, 78 % of the students from the engineering group, and 100 % from the other group, mentioned that by creating games, they mastered the different chapters better than with the classic method of revision. These two experiments demonstrated that we succeeded in achieving our initial goals. However, even if some students found creating games required more time than studying for a standard test, all of them appreciated (100 %) the experiment and requested to repeat it in the coming years, moreover, they (85 %) even supported to carry it with other modules. The overall evaluation of this experiment was positive by students, whether it is for digital or board games. Its originality was also well appreciated even though; some students found that this assessment strategy took too much time. We can infer from our conversations with the students and their responses that we were successful in highlighting the best understanding of the course. Students even said that this technique gives them a stronger sense of chapter mastery than typical exam revisions. Thus, this study supports the findings of previous research on the beneficial effects of game design on learning.

Furthermore, this experiment was easily adaptable to the different modules. It is important to point out that the fact that some of our students were computer scientists did not influenced their willingness to embrace the concept, the others did it too. At this level, we insist on the distinction between the positive impact of the creation of a game on learning and the environment of its creation. For the success of such an experiment, it is recommended to select an environment adapted to the background of the creators of these games. Thus, we have given free choice to our computer science students, but we have offered an affordable environment, Scratch, to others. The aim is to prevent the environment from becoming an obstacle. On the other hand, during our conversation, the students in the Innovation Master's program mentioned that the evaluation of their games was creative and inspiring. This is particularly true because their games are relevant to the businesses of their firms. In addition, many disregarded the idea of serious gaming before using our module. Therefore, developing serious games to evaluate students may also present a chance to raise awareness of the significance of this idea among various corporate employee profiles. To remain current with changing business practices, businesses must maintain this awareness. 92 % of our engineers want to inform the company's decision-makers about SG. Seventy percent intend to implement a SG project at their place of employment. The positive results of these experiments encouraged us to renew it at the start of the 2023–2024 academic year. We conducted it with two groups of students enrolled in two different master's degrees at the University of Tunis, and for both of them we taught the module "Business Games". In the first group, sixteen students were enrolled in the previous master's degree at ENIT High School, and many of them are engineers in different domains. In the second group, sixteen students were enrolled in a new master's degree at the ISG Institute, which is "Enterprise System Engineer". The majority of these students have a licensed diploma in computer science, but some of them have a diploma in business. Students of both groups answered the previous questionnaire. Once again, the students' answers confirmed that the creation of the game leads them to master the course more than when revising for a paper exam and also to deeply master the module content. They also indicated that this assessment approach is more effective than traditional exams. Like the previous experiments, students proposed to extend the game creation to other modules such as the module "Knowledge Management", or the "Personal Development" module, and also those where there is Interactivity, Creativity and Innovation. It is necessary to point out that despite the positive impact of the creation of the game on learning and its adaptability to different modules, it presents some difficulties. The teacher who will conduct such an experiment has to deal with reluctant students from the very beginning, especially non-computer scientists. Even if they end up buying into it and enjoying the experiment, the teacher needs to support them and give them more guidance. Administrative constraints can also discourage teachers. Indeed, if the institution only recognizes the evaluation on paper, the student's investment in the creation of the game will not be reworded. The selection of the game's development environment is also a crucial element in the success of such an experiment.

5. Conclusion

Educational researchers who are interested in games as learning environments have valued learning through their creation. The impact of the game-creation process on students' learning was also confirmed by our experiments that we conducted in during the academic years 2022–2023 with different student profiles. Thus, following the creation of their games relating to the modules that we taught, the students confirmed that this reinforced their mastery of the modules. Our experiments were generally appreciated, especially their innovation in learning and assessment. All of the different profiles of students who participated in our different experiment agree on the benefits of our evaluation approach. They all asked to reproduce such experiments in our modules or even to extend them to other modules. The success of our experiments and the requests from students to renew them has led us to test them again during this new academic year 2023–2024. In addition to digital games, these experiments can also apply to board games that are technically less demanding. However, it is necessary to mention that some constraints can lead to failures. For example, it is necessary to select the right game development environment. It is also necessary to deal with administrative constraints.

Ethics statement

We have no Ethics commission in the university.
Students were aware that this is an anonymous questionnaire.
There is no information that can identify those who answer our questionnaire.

Data availability statement

https://drive.google.com/file/d/1iADfEZXUd7wVpQJmOi0l9EmUE1h1Qibm/view?usp=sharing
https://drive.google.com/file/d/1OALiGexd3qxbyBPycYFh3zQqFcxnyyD-/view?usp=sharing.

CRediT authorship contribution statement

Hedia Mhiri Sellami: Writing – review & editing, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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