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Assessment of Cognitive Engagement and Interest of Medical Students in a Serious Game Design Activity

Ihsen Zairi [a, *], Khadija Mzoughi [a], Mohamed Ben Dhiab [b], Imtinene Ben Mrad [a]

[a] Department of Cardiology, Medical University of Tunis, University of Tunis El Manar, Tunis
[b] Department of Legal Medicine, Medical University of Sousse, Tunis

Abstract

This study aimed to assess the cognitive engagement and interest of third-year medical students by offering them an educational activity in the designing of a serious game.

Methods: four successive groups of twelve students each (a total of 48 students) in the third year of medical training participated in an activity of designing serious games. This study was carried out during a summer internship in the cardiology department of Habib Thameur Hospital. The course of the designing of serious games with students spread over 4 weeks with 10 hours face-to-face and 10 hours of remote work.

Results: a total of 48 students were enrolled. Of these 48 students, 36 were female. The means and standard deviations of the cognitive engagement scale experienced by the students were high. The means and standard deviations of the interest scale experienced by the students were high. There are significant and positive relationships between sustained and maintained situational interest and the different cognitive engagement scales. The correlation between individual interest and peer collaboration, cognitive problem solving, interactions with instructors, and learning management was significant.

Conclusion: using serious game development-based learning as a learning method for medical students' suggests a promising approach for developing cognitive engagement and interest.

Keywords: serious game, motivation, interest, collaboration, learning, creativity, design.

1. Introduction

Cognitive engagement of students towards an educational intervention has been positively correlated with learning outcomes and behavior change (Donkin et al., 2011; Perski et al., 2017).

* Corresponding author
E-mail addresses: ihsen.zairi@fmt.utm.tn (I. Zairi), khadija.mzoughi@fmt.utm.tn (K. Mzoughi), mbdhiab@yahoo.fr (M. Ben Dhiab), imtinene.benmrad@fmt.utm.tn (I. Ben Mrad)

Designing educational interventions to support the engagement of medical students is therefore important to improve their performance (Wang et al., 2016). A higher level of student engagement generates deep learning, active participation, and a positive response to challenges

Developments in digital technologies now offer teachers the opportunity to diversify the media they use for teaching. Faced with a new generation of educational media that has recently emerged, it is recognized that serious games or serious games can improve the acquisition of knowledge and skills by learners and increase student motivation (Laurent, 2010; Alvarez et al 2006). Computer gaming technology has increased the opportunities for delivering immersive learning experiences (Bonk, Dennen, 2005; Hill et al., 2006; Smith, Smith, 2006), and so has the challenge of creating pedagogically efficient experiences (Hussain, Feurzeig, 2008; Juzeleniene et al., 2014).

Research indicates that serious games (SG) can improve student performance in many tasks and cognitive skills (Boot et al., 2008).

Learning in SGs occurs through gameplay which is a combination of challenges and design elements (DEs) (Nevin et al., 2014) that engage the learner in challenges that seek the learners' competence (Hamari et al., 2016) and improve the learner's engagement in SGs (Nevin et al., 2014; Wang et al., 2016; Sailer et al., 2017). Challenges can require the learner to experiment, collaborate or compete with other learners (Westera et al., 2008). Three different, but not exclusive, approaches are presented to a teacher to integrate Serious Games into his teaching practice: the use of existing Serious Games with his students, the creation of "tailor-made" Serious Games for his students, and having them create Serious Games directly (Djaouti, 2016).

Indeed, thanks to the "game factories" and "modifiable games" that the teacher can use to create Serious Games that correspond to his needs, it is also possible to imagine educational activities in which the learners create a Serious game (Djaouti, 2016). This approach to designing serious games by students is part of the so-called "active pedagogy" or "project-based learning" approaches, in which the teacher prioritizes pedagogical strategies that promote students' cognitive engagement and interest.

Cognitive engagement in education

From a constructivist perspective, cognitive engagement refers to the extent to which students are attending to and expending mental effort on the learning tasks encountered (Chapman, 2003). According to Pintrich and Schrauben (1992), students' cognitive engagement represents a motivated behavior associated with their persistence on difficult tasks and the usage of cognitive strategies. In education, using written tasks that focus on personally meaningful experiences can facilitate behavioral and/or cognitive changes that lead to knowledge and skill re-construction (Mason, 2001).

Interest as a motivation source in education

Constructivist learning theory acknowledges that learner motivation is a key component in learning (Resnick, Klopfer, 1989). Among many motivation sources, interest has been considered powerful and effective in engaging students during the learning process (Dewey, 1913). In educational research, interest is conceptualized as situational and personal (Hidi, 1990; Hidi, 2000).

The role of interest in cognitive engagement

Interest is often conceptualized as a relational construct that reflects an affective-cognitive relationship between a person and an object, event, or idea (Krapp, 2002).

In education, two types of interest, individual and situational, have been studied concerning the relationship between interest and learning. In research, individual interest is considered to be an individual's predisposition characterized by high attention given to certain events and objects. Individual interest is activity-specific and associated with value and previous knowledge (Wade, 2001). Situational interest, on the other hand, is characterized by instantaneity. A highly, situationally interesting activity can immediately attract students' attention, involve them in the process, and provide instant, positive feelings about the activity (Hidi, Harackiewicz, 2000).

As a construct, situational interest is structurally more complex than individual interest, which depends on a person's existing knowledge and value about an activity. Situational interest has been articulated as multidimensional. Deci (1992) proposed that it encompasses person, activity, and social context dimensions. The Person dimension consists of experiential and dispositional components. In a situationally interesting environment, the individual will experience quality attention, a sense of delight, exploration intention, time alteration, and desire. A person evaluates enjoyment based on the attentional demand and sense of delight that occur when he/she engages in an activity. Exploration intention, time alternation, and desire represent the stimulation the activity generates. Deci (1992) assumed that these components were more likely to arouse a person's perception of situational interest and might increase the person's intrinsic motivation to engage in the activity. In the Activity dimension, the challenge and novelty of activity are central to situational interest. People are likely to experience situational interest when the activity is optimally challenging or novel to them. Challenge is defined as the difficulty level associated with the activity and has been identified as a motivational factor that may attract individuals to engage in an activity (Harter, 1978).

However, to our knowledge, no empirical study has delved into an in-depth understanding of the links between student cognitive engagement and interest in a serious game design activity in medical education.

This study aimed to assess the cognitive engagement and interest of third-year medical students by offering them an educational activity in the designing of a serious game.

2. Methods

2.1. Study design

This was a prospective study performed for 2 years (2018–2019 and 2019–2020).

2.2. Population and location of the study

Four successive groups of twelve students each (a total of 48 students) in the third year of medical training participated in this study carried out during a summer internship in the cardiology department of Habib Thameur Hospital, the third-year medical student must do a summer internship in the department of cardiology.

2.3. The course of the educational activity on the designing of serious games with students

The training schedule spread over 4 weeks with 10 hours of face-to-face and 10 hours of remote work. The course is structured in five main periods to create prototypes (Figure 1).

Fig. 1. Prototype of the course on serious game design

The first step: Introduction and discovery of Serious Games

Reception of the students by the facilitator with an explanation and introduction of the objectives of the training and the concept of "Serious Game", After this short introduction, we invite the students to discover examples of Serious Games for themselves. The goal of this phase is for students to experience the immense variety of affordable themes through video games.

The second step: Theoretical course on video game design methodologies and tools

The students are introduced to digital game design to facilitate the decision-making concerning game and learning mechanics and evaluation. The table below introduces the methodological procedure and reflective questions in each of the six steps of the proposed methodology (Table 1).

The design elements in a serious game to be assessed are (Maheu-Cadotte et al., 2018): avatars, levels of difficulty of the challenges, performance tables or graphs, a narrative discourse that serves to organize the events of a story in a logical or temporal order, points and the time limit that is allowed for the learner to achieve a specific challenge.

We reveal to our students the theme they will have to deal with through their Serious Game design by setting the learning objectives to be achieved. The themes set for the training were chest pain and dyspnea. The students were divided into two teams and started working on their projects. Throughout this phase, the teacher will have to support and guide the students as to the relevance of their game to the subject.

Each team should develop the prototype for their game design. The students are not required to engage in the development of the game. They are only required to produce a prototype of the look and feel and interface that could help a third person to understand the game interface and interact.

Table 1. Game design methodology

Heading level	Font size and style
Learning objectives	Learning objectives are the key point in starting to design the digital game-based learning (DGBL) activity. In this step, the students are invited to identify the formal or informal learning context, define which of the learning objectives will be part of the learning assessment and which type of feedback (or group awareness) will be offered as a display of progression to the learners during the game or gamification activity
Learner-centered need analysis	The learner-centered need analysis aims to analyze the learners' prior knowledge and competencies (PKC) to organize the learning objectives and the optimal difficulty to try to achieve a certain level of flow (Csikszentmihalyi, 1990). Based on the learners' diversity in terms of PKC, the team could decide to organize the learning modalities to adapt the game to the diversity or evaluate the cooperative game dynamics that could help overcome the learners' PKC diversity. The learner-centered need analysis should also analyze the learners' language and computer literacy, their preferences, context, and technological resources to make decisions in the following steps
Game modalities	To decide the game modalities, the learners are invited to identify the existing serious games that could fit the learning objectives. In case an existing serious game matches the objectives, they should identify the pedagogical integration requirement. In case there is not an existing serious game fitting the requirements, the teams could decide to repurpose an existing game. A third alternative is to design and create a game. Furthermore, the teams can opt for educational gamification and add the game components (e.g. public scoring and competitive team, reward system…) to an educational situation. All the students enrolled in our course the students decided to create their game because no existing serious games fitted the learning objectives
Heading level	Font size and style
Game rules, learning and game mechanics	The teams should decide the individual or collaborative context of the game and define the game rules. The game rules should be aligned with the learning objectives and the learning assessment and feedback to incentivize the learning progression in the game. The game mechanics structures the interaction and control processes allowing the player to advance in the game. The teams are introduced to the existence of primary and secondary game mechanics (Fabricatore, 2007)and are invited to identify the learning mechanics and game mechanics based on the LM-GM model proposed by Arnab and collaborators (Arnab et al., 2015).
Learning assessment and feedback	In this phase of the game design methodology, the team should analyze the effective impact of the game on the learning objective achievements. The learning assessment and feedback should derivate from the learning objectives. According to the needs identified in the second phase (learner-centered need analysis), three main types of assessment could be introduced in the game: diagnostic, formative, and summative assessment.

Gaming and learning experience	Individual and collective feedback could be displayed to the players through knowledge group awareness widgets (Chavez, Romero, 2012) to ensure the learner is aware of her/his progression This last phase aims to evaluate the player gaming and (positive) learning experience. The teams are introduced to the works of Kiili concerning the flow experience (Kiili, 2005) and the criteria for improving it. Kiili focuses on the importance of immediate feedback, clear goals, and challenges that are matched with the current learners' knowledge and skills to place them in the flow activity state

The third step: design and production of Serious Games

As a design tool, we offer them a free version of the "VTS Editor" software with an introductory course in its handling.

The fourth step: Presentation and evaluation of completed projects

- At the end of the training, an anonymous self-assessment questionnaire composed of 39 items [All items were measured using Likert scales ranging from one (very much disagree) to seven (very much agree)], and was submitted to the student in two parts:

The first part of the questionnaire measure student cognitive engagement. For the design of the questionnaire for this study, we adapted questions focused on measuring student cognitive engagement from the study of J. Lee (2019).

In this research through a questionnaire, they analyzed six factors in student engagement in the e-learning environment: factor 1. Psychological motivation (6 items), factor 2. Peer collaboration (5 items), factor 3. Cognitive problem solving (5 items), factor 4. Interactions with instructors (2 items), factor 5. Community support (3 items), and factor 6. Learning management (3 items). Averages and medians of the students' responses to the questionnaire were calculated. An average of 7 expresses that, on average, the students are very engaged in the serious game design activity. However, an average of nearly 1 express that, on average, students are not engaged in serious game design activity.

The second part of the questionnaire evaluates the three models of interest using the individual and sustained scale for the serious game (Chainon et al., 2014); composed of 12 items subdivided into three sub-scales assessing the three types of interest: individual interest, sustained situational interest and maintained situational interest.

2.2. Statistical analysis

Data were analyzed using SPSS software version 19.0.

Three different statistical methods were employed. To determine the degree of students' cognitive engagement as well as their interest, the means (M) and the standard deviation (SD) were utilized. The links between 2 quantitative variables were studied by the Pearson's rank correlation coefficient.

We also conducted a series of hierarchical multiple regression analyses to see the influence of interest on students' cognitive engagement, and factorial ANOVA was run to analyze the effect of age, and gender on learners' cognitive engagement.

In all statistical tests, the significance level was set at 0.05.

2.3. Ethical approval

The study was approved by the research ethics board at the institution, project reference HTHEC-2021-17. Participants provided informed consent before participation.

3. Results

3.1. Demographic Characteristics of Participants

A total of 48 students were enrolled. Participants ranged in age from 20 to 22 years (M = 21.25, SD = 0.6), and of these 48 students, 37 were female

3.2. Results of cognitive engagement

The reliability of the instrument used to test levels of cognitive engagement, the relationships between these levels and test variable, and the highest predictor of cognitive engagement were highly reliable. The reliability of the Survey of student cognitive engagement was determined by using a statistical analysis program, SPSS. The alpha reliability for the 24-items instrument was 0.84.

The scores for cognitive engagement ranged from 5.6 to 6.2.

Table 2 shows that the means and standard deviations of the cognitive engagement scale experienced by the students were high.

The results displayed in Table 2 showed that the students generally felt motivated in the serious game design activity, with a mean of psychological motivation (M = 5.6, SD = 0.6). More interestingly, the results suggested that students' learning management level was quite high (M = 6.2, SD = 0.4). Interaction with the instructor showed almost the same results.

3.3. Results of interest dimensions

Reliability for the Survey of student interest using the individual and sustained scale for the serious game interest was determined by using a statistical analysis program, SPSS. The alpha reliability for the 12-items instrument was 0.83.

The scores for interest ranged from 6.3 to 6.4.

Table 3 shows that the means and standard deviations of the interest scale experienced by the students were high.

The results displayed in Table 3 showed that the students generally felt an individual interest in the activity of serious game design. The results suggested that students sustained situational interest level was quite high (M = 6.4, SD = 0.3).

3.4. Correlation between cognitive engagement and interest

We examined the bivariate correlations between learners' cognitive engagement and interest. Table 4 show significant and positive correlation between individual interest and peer collaboration, cognitive problem solving, interactions with instructors ($p = .00 < .01$), community support and learning management ($p = .05$), between sustained situational interest and psychological motivation, peer collaboration ($p = .00 < .01$), cognitive problem solving and interactions with instructors ($p = <.05$).

3.5. Students' interest based on age, gender, psychological motivation, peer collaboration, cognitive problem solving, interactions with, community support, and learning management

The multifactorial analysis of variance (factorial ANOVA) was performed to investigate students' individual interest based on age, gender, psychological motivation, peer collaboration, cognitive problem solving, interactions with, community support, and learning management. In particular, the factorial ANOVA analysis indicates significant interaction effect only between individual interest and peer collaboration ($p = .00 < .01$), and learning management ($p =.07$),

3.6. Students sustained situational interest based on age, gender, psychological motivation, peer collaboration, cognitive problem solving, interactions with, community support, and learning management

The multifactorial analysis of variance (factorial ANOVA) was performed to investigate students' individual interest based on age, gender, psychological motivation, peer collaboration, cognitive problem solving, interactions with, community support, and learning management. In particular, the factorial ANOVA analysis indicates significant interaction effect only between sustained situational interest and peer collaboration ($p = .00 < .01$).

Table 2. Means, medians, and standard deviations of cognitive engagement (N = 48)

	Mean	Median	Standard deviations
psychological motivation	5,6	6	0,6
peer collaboration	5,9	6	0,7
cognitive problem solving	6	6	0,6
interactions with instructors	6	6	0,6
community support	6,1	7	0,6
learning management	6,2	6	0,4

Table 3. Means, medians, and standard deviations of interest scale (N = 48)

	Mean	Median	Standard deviations
Individual interest	6,3	6	0,4
Sustained situational interest	6,4	6	0,3
Maintained situational interest.	6,4	6	0,4

Table 4. Correlation between cognitive engagement and interest

	Individual interest	Sustained situational interest	Maintained situational interest.
psychological motivation	,274 ,059	,378** ,008	,415** ,003
peer collaboration	,608** ,000	,536** ,000	, ,319* ,027
cognitive problem solving	,453** ,001	,326* ,024	,239 ,102
interactions with instructors	,506** ,000	,322* ,026	,323* ,025
community support	,350* ,015	,264 ,070	,325* ,024
learning management	,452** ,001	,264 ,069	,198 ,177

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

4. Discussion

The purpose of this study was to examine the relation between students' situational interest, and cognitive engagement during a serious game design activity. This study highlights that the educational activity of creating a serious game by the students can enhance the cognitive engagement and interest, of medical students.

The use "in the field" of the various approaches of the Serious Game to its educational practice is far from being equivalent. The “use” approach seems to be the most common in the teaching community. The "create" and "create" approaches remain confined to the experimental scale, as they are more complex to implement.

It seems that serious games allow a better engagement of the students in the task (Girard et al., 2013).

Kafai (2012) experimented with the creation of the serious Game by pupils in primary school and concluded that this pedagogical approach leaves a greater part to personal creativity and makes it possible to respect the different styles and rhythms of specific learning.

The work of Djaouti and Alvarez (2013)carried out by Masters level students on the creation of Serious Games, revealed a strong motivation of the students to carry out documentary research to be able to create a game on the chosen theme and the opportunity.

Several authors (Kafai, 2006; Seymour, 1993; Harel, Papert, 1991; Ouahbi et al., 2017), have specified that the creation of serious games by learners, defined as a constructivist approach, appears to be potentially more suited to taking into account the different learning styles specific to learners and makes it possible to stimulate their cognitive engagement and interest. Our results are consistent with these studies. The activity of creating serious games with the students helped to develop their cognitive engagement, individual interest, and sustained interest with a good overall scale.

In line with interest theories (Dewey, 1913; Hidi, Harackiewicz, 2000; Schiefele, 2009) and our hypotheses, results suggested that students’ experience of interest during serious game design activity predicted all forms of cognitive engagement assessed, as well as an increase in their interest in ways that might maximize their learning experience.

Such findings provide insight into pathways through which situational interest may come to influence students' cognitive engagement. These various forms of engagement are considered to be precursors to learning and achievement (Roderick 2001; Willingham, 2002), as well as attendance and graduation over the long term (Croninger, Lee, 2001).

This study suggests that the experience of interest during serious game design activity serves as a platform to set these pathways into motion each day.

The relations between situational interest and peer collaboration, individual interest, peer collaboration, and learning management were stronger, a finding that may point to the relative strength of individual versus situational interest for supporting learning-related outcomes over the long run (Hidi, Renninger, 2006).

Our study indicates that the interest scale experienced by medical students was high. This finding strongly confirms the findings of other studies which state that serious games manage to trigger and maintain situational interest for a longer time, and it might have positive effects on the subsequent individual interest (Meyer, Sørensen, 2008).

These results provide evidence for our expectation that interest would play a greater role in guiding students' cognitive engagement when the student is placed in a creative situation, he has greater freedom to develop his relationship with educational content, and therefore to choose his way of assimilating it.

As the consequences of the learning approach, we suspect that extrinsic motivation, that is, a state of wanting to perform a specific activity in each situation for the sake of some external outcome (Ryan, Deci, 2000), became a more powerful predictor of students' learning-related thoughts and behavior, subtly "crowding out" the role of interest.

We have identified many examples of constructivist approaches based on the creation of video games, such as the work of Overmars (2004) and Claypool (2005) which are based on Game Maker, or those of El-Nasr (El-Nasr, Smith, 2006) which use "modding" tools.

According to studies that have been carried out with modding tools (Laukkanen, 2005; Yucel et al., 2006; De Prato, 2010), the choice of tool is very important and must be aligned with the audience and the intended educational objectives.

In our study, which aimed to make students aware of "Game Design", while bringing them to work in groups, the choice of a simple tool allowing to create modest achievements turned out to be more relevant than a more elaborate tool allowing to obtain richer creations. That's why we used the free version of the VTS Editor software, which is easy to use with built-in tutorials.

The evidence points towards the suitability of serious game design activity in supporting a learning design for cognitive engagement. It provided an engaging learning environment by allowing for higher levels of self-pacing, multi-modal representation, multiple points of access, collaborative discussion, and reiterative learning. This success in facilitating cognitive engagement supports findings from the literature which suggest that learning technologies, when used effectively, can play a key role in stimulating curiosity and interest and in facilitating and sustaining engagement (Arnone et al., 2011).

Serious games might also encourage learners to hold positive attitudes toward academic tasks with strong self-regulation if they were immersed in the gaming situation. Positive attitudes help learners to produce better academic achievements. Thus, it is reasonable to conclude that serious gaming leads to significantly more positive attitudes than traditional learning (Hwang, Chang, 2011).

However, the implementation of such an educational activity comes with several conditions. First, it seems obvious that it is above all necessary for the teacher to be interested in this approach and to fully master the serious theme that he is proposing to his learners. But the teacher must also be able to support them in handling the different tools they will use to create their Serious Games.

In terms of constraints, the question of choosing a "game factory", or a game to "modify", which is suited to the skills and time available, remains as central as the "create" approach. However, this approach also poses a new problem: that of the teacher's posture. Indeed, this kind of activity fits in so-called "active pedagogy" or "project-based learning" approaches, in which the teacher must, for a time, leave his masterful posture to take on a supportive role. This refers more generally to the question of support for teachers opting for this kind of approach (Alvarez, 2006; Djaouti, 2016).

The limits of the study

- The small number. But, considering the time devoted to this activity, it was difficult for us to recruit a larger sample.

- the students who took part in the study are possibly more engaged since they were volunteers, which could generate a positive prejudice at the start, and which would cause the results on cognitive to indicate that it is higher than it is in reality**.**

- students may underestimate themselves or even overestimate themselves in terms of their cognitive engagement; therefore, care must be taken in interpreting data relating to different perceptions.

Reflection and future practice

What was presented here was an evidence-based learning tool, that could be used as an aid in a task designed to promote deep cognitive engagement and interest amongst students. It was the experience of a serious game design activity; the task was seamless and easy to manage from an educator's perspective. As such, this should encourage educators to seek ways to innovate their teaching methods and to consider ways in which technologies can be employed pedagogically to promote learning and engagement.

This study also promotes exploring what other technologies could be used to support learning designed to promote cognitive and interest

On reflection, the introduction of a serious game design activity in medical education intervention is a worthy cause to facilitate cognitive engagement and interest. However, it is important to note that technology can be used superficially and in ways that are of no added value to students; thus, it is vital to ask the question of whether the incorporation of technology into an instructional design is an enabler or a distraction.

5. Conclusion

The diversification of educational strategies can be hampered by certain obstacles, in particular the additional planning time required for their designs. The results obtained within the framework of this study show that the activity of creating serious games by students seems to have a positive effect on their cognitive engagement and demonstrate that it is profitable to counter these obstacles, to place student learning, and opt for a variety of instructional strategies to maintain strong engagement and interest to learn in students throughout the course. Thus, this research provides educational actors with results based on empirical research data that encourage further reflection on the use of diversified educational strategies in the faculty of medicine. However, given the small number of students who took part in this study, these results will need to be confirmed by other experiments repeated throughout the academic year.

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7. Conflict of interest

No conflict of interest.

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