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A mind-mapping guide based on Unified Modeling Language for developing educational role-playing games

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Abstract: Designing an educational game can be a difficult task for individuals who do not have appropriate background towards game developments. Several game genres exist in the literature which can make beginners confused about which are the appropriate or required game elements and functionalities for a particular game genre. At the same time, many studies highlighted the effectiveness of mind-mapping techniques in enhancing learning and thinking task. Therefore, this study deploys the powerful graphical representation of Unified Modeling Language (UML) class diagram to present a mind-mapping guide for people who are developing educational role-playing games. A total of 113 students used the developed mind-mapping guide in a public Tunisian University, and the obtained results showed that the guide can: (1) significantly enhance beginner students' level of knowledge regarding developing role-playing educational games; and, (2) promote the creative thinking when it comes to imagining educational role-playing game scenarios. Also, these results showed that students have a favorable attitude towards using the mind-mapping guide to learn and design their games.

Keywords: Educational games, Mind map, Unified Modeling Language, Role-playing, Game design

1. Introduction

Various game generators and engines are available in the literature that have made the process of developing new games, including educational ones, easier. They significantly help in reducing the effort required for the development of games by including in game engines basic functions that are common to a number of games (Gelman, 2018; Juang, Hung & Kang, 2011). Consequently, beginners of game development, including educators and students, will be able to create their own games without having any particular programming skills. However, designing a good game still need appropriate background knowledge and skills about games. Many game genres with different elements and functionalities exist in the literature. Thus, it becomes important to collect enough information about a specific type of the game in order to effectively develop a better game of that type. In this context, Baranowski et al. (2016) stated that an effective game design research must examine the appropriate game features to be included in the game in order to engage users and facilitate game transfer to real-life behaviors. Besides, each game genre contains different features based on its characteristics (Paavilainen, Alha & Korhonen, 2017). Therefore, providing a guide, which clearly defines game elements,

functionalities and features of a given game genre, would help beginners in the game development process. The proposed guide also aims to support students' creative thinking in providing original game scenarios that could be implemented as an educational game. A game scenario is a set of activities that the players have to go through in order to achieve the game objective.

De Troyer, Janssens and Vandebosch (2013) pointed out that mind-mapping tools are more suitable to structure ideas and concepts. Additionally, these tools provide a structure for thinking in a nonlinear manner. Specifically, this study adopts Unified Modeling Language (UML) class diagram to present a mind-mapping guide to support the development of educational role-playing games (RPGs). To the best of our knowledge, there were no examples, models or guides found in the literature which support beginners for developing role-playing educational games.

The rest of the paper is organized as follows: Section 2 presents the developed mind-mapping guide for beginners. Additionally, it presents the motivation behind the need for it. Section 3 describes the used method to validate the game design guide, while Section 4 presents the results. Finally, Section 5 discusses these results, concludes the study with a summary of the findings and potential research directions.

2. The development of Mind-Mapping guide

To develop the mind-mapping guide, "educational role-playing games" element (noted as RPG in figure 1) was the starting point which will be related to the other elements and components. Specifically, to provide a realistic generic guide, all the game elements, features and functionalities presented in this guide are based on various educational role-playing games in the literature. Thus, a comprehensive literature search was conducted to identify these games and use them to create the guide using various keywords, such as "educational games", "role-playing educational games" and "game-based learning", in different electronic databases, such as IEEE Xplore and ScienceDirect. In particular, this review was limited to only journal papers because they contain more descriptions about the implemented educational games that could be used in the developed mind-mapping guide.

As shown in Figure 1, all the game elements are represented as classes ( ). The game functionalities on the other hand are represented with different relations between classes (which are game elements). For instance, all educational role-playing games offer the students a character to control and a virtual environment to learn and play within it. Therefore, the relation between the RPG class, the virtual environment class and the character class in the proposed guide is "composition" ( ) (i.e., the game environment and character classes are mandatory in RPGs). In addition, some game elements are optional and not always found within the virtual environment, thus they are related to the virtual environment class using the "aggregation" relation ( ). Furthermore, different missions are found in RPGs which can be in the form of combats or challenges, hence the mission class and both combat and challenge classes are related using the "inheritance" relation ( ). In particular, various types of challenges are found in RPGs namely time, memory/knowledge cleverness/logic, endurance and dexterity (Feil & Scattergood, 2005). Thus, the feature "enumeration" is used with the challenge class. Finally, the game activities which are used to transmit the learning content to students during the learning-playing process, as shown in able 1, are presented using "association" relations ( ). These relations highlight how the classes (game elements) communicate together.

As shown in Figure 1, the developed mind-mapping guide highlights the functionalities that beginners can design with the game elements (defined using classes and relations). Consequently, they are all well-informed about the game elements and functionalities that can be included within their role-playing games. Particularly, the internal architecture that this guide would present about these games should help beginners know the different game elements to implement within their game. Furthermore, the developed guide can support them to think and generate their game scenarios by referring to the way the game elements (represented as classes) communicate with each other (represented as relations). However, attributes and methods are not specified in this proposed guide because they are beyond its main objective highlighted above. It should be noted that this developed mind-mapping guide was refined and validated by fifty one international game developers before being used with students, as highlighted in (Tlili, Essalmi, Ayed, Jemni, & Kinshuk, 2016).

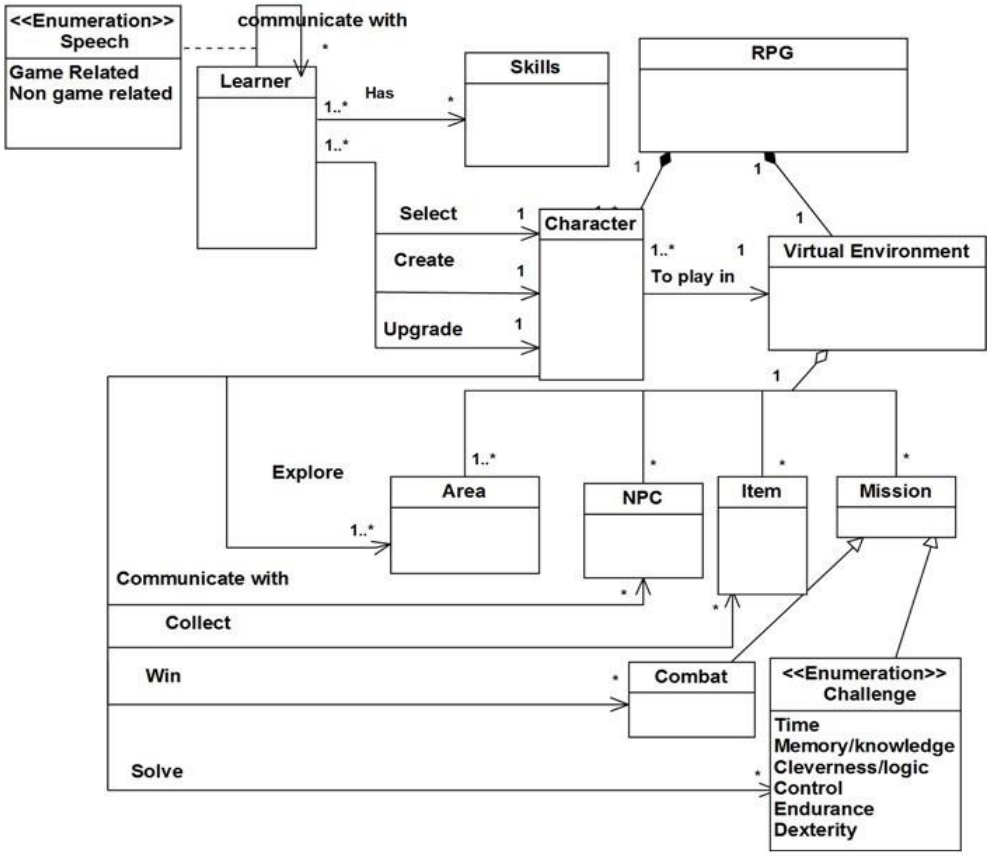

Figure 1. The developed mind-mapping guide for game development.

3. Method

This section investigates the effectiveness of the proposed mind-mapping guide in supporting beginner students design educational role-playing games. Specifically, this study investigates the following research questions.

1. Does the developed mind-mapping guide significantly enhance the students' level of knowledge towards designing educational role-playing games in comparison with the traditional learning method?
2. Does the developed mind-mapping guide enhance the students' creative thinking when it comes to designing educational role-playing game scenarios in comparison with the traditional learning method?
3. Do the students have a favorable attitude towards using the developed mind-mapping guide?

3.1 Participants

One hundred and thirteen students participated in this experiment in a public Tunisian University after the Institutional Review Board (IRB) approval was obtained. These students, aged between 21 and 23, were undergraduate students majoring in computer science. All of them are enrolled in the "game development" course which was recently added to the curriculum. Additionally, they all had taken UML courses earlier last year. Furthermore, they had all reported that they had never taken any game design or development courses (public or private courses) before and were considered as the beginners of game development.

3.2 Procedure

Due to the University context limitation, it was very difficult to divide students to two groups, namely control and experiment groups. Therefore, a within-subjects design experiment also known as repeated

measures design was applied (Ellis, 1999) to validate the effectiveness of the mind-mapping guide in supporting beginners to design their educational role-playing games. In this experiment, the same group of participants serves in more than one learning method to learn designing role-playing games. In this context, during the second semester, one hundred and thirteen beginner students studied the design of educational game development using the traditional learning method namely lectures (first learning method) for six weeks (one hour and half per week). These students then took a written test, namely the learning and creative thinking test, which includes questions regarding various knowledge they learned and question asked them to imagine an educational role-playing game scenario that can be implemented.

After that, as a second learning method, the students used the proposed mind-mapping guide to learn about role-playing games for six weeks as well (one and half hours per week). Each of the students (113 students) was given the proposed mind-mapping guide to get to learn about role-playing games and its possible functionalities, features and elements. The instructor then has started drawing on the board this guide (step by step) and going with the students through each branch and each element (class) by analyzing it and explaining each part. Also, he answered their questions and discussed their suggestions to ensure that this proposed mind-mapping guide is fully understandable. Finally, the students took the same learning and creative thinking test regarding the design of educational role-playing games. Furthermore, these students gave their opinions regarding learning with the mind-mapping guide through unstructured interviews.

3.3 Data collection

To collect data from students while learning, the following three methods are used.

- *Level of knowledge questions:* The learning test is a paper-based written test, aims to investigate the impact of both learning methods (lectures and the developed mind-mapping guide) on the students' level of knowledge regarding the design of educational role-playing game. The students were asked to answer questions regarding various knowledge, such as game elements, functionalities, that developers should know while designing their educational role-playing games.
- *Creative Thinking test:* Inspired by various thinking and creativity instruments, such as Guilford (1967) and Torrance (1966), in the test there is a question aims to investigate the effectiveness of both learning methods (using lectures and the developed UML guide) in simulating creative thinking within students to generate educational role-playing game scenarios. In this context, the students were asked to imagine an educational role-playing game scenario that can be implemented and write it down. To validate these proposed game scenarios, a group of experts, including game designers and developers, were selected to review these scenarios and validate them based on the following scoring: (1) Three points on Elaboration - amount of details given by students regarding their educational game scenarios; (2) Three points on Originality - Degree to which the proposed game scenario is original and not similar to an already developed games in the literature/game market; and, (3) Three points on Implementation - Degree to which the proposed game scenarios can be implemented in the future. A maximum of nine points can be obtained by students on their proposed educational role-playing game scenarios.
- *Unstructured interviews:* It was used to collect the opinions of students regarding the proposed guide. This instrument is very flexible and allows participants to give researchers their most honest and direct opinions. In the 15-miniute interview, students can talk freely about the importance of the mind-mapping guide.

4. Results

4.1 Impact of the mind-mapping guide on students' level of knowledge

The results of the two learning tests were analyzed using the paired samples t-test method. This method is appropriate in this context because the same group of students answered both learning tests (after learning with lectures and mind-mapping guide). In this case, the null hypothesis is that there is no

difference between the mean score of the two level of knowledge tests. Table 1 presents the obtained results. As shown in Table 1, the mean of the level of knowledge test results after using the mind-mapping guide was higher than the test results after taking lectures. This is seen where the mean difference is equal to 7.65. Particularly, this difference was significant since the p value is equal to .01 and less than 0.05. Consequently, the null hypothesis is rejected. Therefore, the mind-mapping guide as a learning method has significantly enhanced the students' knowledge regarding designing educational role-playing games, compared to the lectures learning method.

Table 1. *Paired samples t-test results of the level of knowledge test*

Pair 1	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Dev	Std. Error Mean	95% CID				
				Lower	Upper			
Test 2 - Test 1	7.65	3.95	.37	6.92	8.39	20.69	112	.01

4.2 Impact of the mind-mapping guide on students' creative thinking

Experts considered that scenarios which got 5 points or more are considered valid. The number of valid game scenarios using the first learning method (using lectures) is very limited and only has SIX scenarios. However, after using the mind-mapping guide, the number of valid game scenarios is improved to have FORTY-SIX scenarios. This is seen when almost half of the students were able to write a valid game scenario. Thus, it can be deduced that the internal architecture this guide presents about these games can help students to know the different game elements to implement within their game and how these elements to communicate to generate a game scenario that could be implemented.

Furthermore, the creative thinking test results were analyzed using the paired samples t-test method. The null hypothesis is that there is no difference between the mean score of the results. As shown in Table 2, the mean value of the results after using the mind-mapping guide is higher than the results after taking lectures. This is seen where the mean difference is equal to 13.12. Particularly, this difference was significant since the p value is equal to .00 and less than 0.05. Consequently, the null hypothesis is rejected. Therefore, the mind-mapping guide as a learning method has significantly enhanced the students' creative thinking regarding imagining educational role-playing game scenarios, compared to the lectures learning method.

Table 2. *Paired samples t-test results of the creative thinking test*

Pair 1	Paired Differences					t	df	Sig.(2-tailed)
	Mean	Std. Dev	Std. Error Mean	95% CID				
				Lower	Upper			
Test 2 - Test 1	13.12	1.95	.21	.67	1.64	4.85	112	.00

4.3 Impact of the mind-mapping guide on students' opinions

Students were asked to freely give their opinions about the proposed guide, as a learning material; did they find it effective and helpful? Did they find it interesting or not? This helped to further evaluate it through their given feedback. As a result, eighty students found the mind-mapping guide helpful, nine students found it hard to understand, ten students did not give any feedback and finally fourteen students gave different feedback (e.g., the mind map guide would be efficient if it contains some descriptions). Based on these statistics, we can conclude that the students have a favorable attitude toward the proposed mind-mapping guide.

5. Discussion and conclusion

Buzan and Buzan (1996) mentioned that the human brain is drawn to graphics more than words, thus mind-mapping should always relies on graphics. Also, they mentioned that the use of graphics and no linear branches stimulate the entire brain. This study presented a mind-mapping guide to support the design of educational role-playing games for beginners. Based on the obtained results, the presented mind-mapping guide conceived in graphics is very effective for students learning the design of educational role-playing games.

Boley (2008) found that the learning outcomes of nursing students who have used mind-mapping are much better than those who have not used mind-mapping. The obtained findings also showed that the developed mind-mapping guide can help beginners enhance their knowledge regarding educational role-playing games compared to the traditional method. Additionally, Wu and Chen (2018) stated that mind mapping can be used as a learning tool to promote thinking in both the left and right brain hemispheres of a student. Spencer, Anderson and Ellis (2013) stated that mind-mapping can enhance creative thinking and knowledge attainment. For instance, Wang, Ding, Xu, Wei and Dilinar (2014) found that mind-mapping supports student's divergent thinking and their innovation skills in learning of medical immunology. Based on the obtained results, the provided mind-mapping guide does support the thinking or the imagination task regarding educational game scenario within students compared to the traditional method. On the other hand, some limitations are found in this study which should be acknowledged and further researched. For example, the conducted experiment did not include control and experiment groups. Additionally, the proposed mind-mapping guide requires a short learning session about UML, specifically the class diagram and its different types of relations. This helps to better understand the guide and make full use of it.

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