Designing Serious Videogames through Concept Maps

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Abstract. The purpose of this study was to present and evaluate a new technique through the use of concept maps for the design of serious videogames using Ejemovil Editor. This was accomplished by using a method to easily transform concept maps into directed graphs, which are then used to generate the videogame sequence and the interdependencies between the various elements. With this tool teachers are able to define the storyline of the videogame, incorporating the concepts that they want to teach in a structured way. To these ends, an editor was created using this methodology that allows for the construction of mobile videogames. Teachers that currently use concept maps have evaluated the proposed methodology. Preliminary results show that the proposed methodology for the design and creation of serious videogames for education is appropriate, easy to use, generally accepted and understandable for the end users.

Keywords: Concept Maps, Serious Videogames, Videogames Editor, Videogames Design.

1 Introduction

In the last decades, two technologies have entered the classroom in support of learning. The first are concept maps, which were created by Novak in 1972 and which are used to support meaningful learning [5]. The second technology is the videogame industry, which paradoxically began with Pong in the same year, and which has evolved to become a billion dollar industry [10].

Currently, the development of educational, mobile videogames is limited to the category of trivia games [8]. Several experiences [8][9] have used such devices to take advantage of their potential for using specific messaging services. Mobile Author [15] is an application that aids teachers in creating and maintaining their educational resources on a virtual platform. Some experiences with this application have developed RPG videogame editors, such as RPGMaker [11], which is designed for amateur users. Although this editor provides a great deal of freedom regarding the ability to create videogames, it is not oriented towards the development of videogames in an educational context.

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There are also several experiences based on the use of concept maps as pedagogical instruments that have demonstrated effective results in primary education [1][4][6]. A tool called Concept Gaming [0] can generate concept maps made by a teacher or a learner. Then the students can interact with the concept map in five different game modes by adding concepts or relationships. In this case the result is not a videogame, because the students are directly interacting with a concept map.

Wu et al. (2012) presented a teaching strategy that involved the use of concept maps for the design of videogames [16]. There are also methodologies based on concept maps that facilitate the creation of videogames [2][14]. Bellotti et al. (2013) proposed a serious game model related to cultural heritage, using an approach very similar to the mind-maps concept [2]. Treanor et al. (2012) presented a methodology involving a videogame authoring tool based on concept maps called Game-O-Matic, which generates games to represent ideas [14].

The purpose of this study was to present and evaluate a new technique through the use of concept maps that allows teachers to integrate concept mapping and mobile videogame technologies, enabling them to create serious videogames with content organized by using the Ejemovil videogame Editor [12]. In this case, the students interact with a mobile RPG videogame generated from a concept map.

2 Ejemovil Videogame Editor

Ejemovil Editor was previously developed [12] with the capacity to generate structures similar to concept maps, in order to design and create mobile serious videogames. The idea is to provide teachers with an easy-to-use tool that allows them to create videogames based on the concept mapping technique. Such games can then be provided to students of primary education, who can use them for learning.

The editor generates RPG style videogames, in which the player controls a character that interacts with other virtual players (see Figure 1). In these interactions, the player is presented with a series of questions that have three alternative answers, in which there is only one correct answer. In addition, the questions are progressively unlocked by other associated, dependent questions; in other words, the players must answer certain questions correctly before being able to unlock the questions associated with other virtual characters.

The questions are related to a specific topic, which in the videogame are represented by an icon and a bar that indicates the player's progressive score. Each videogame has a maximum of three topics upon which the questions are based. The maximum score per topic is 100. The maximum score per questions is equivalent to 100 divided by the number of questions associated with that particular topic. The maximum score is assigned when the player responds correctly to a question on the first try, without having made mistakes previously on the same question. When the player responds correctly on the second try, half of the maximum assigned for the question is awarded. Finally, when the player responds correctly after two or more tries, one quarter of the maximum score for that question is awarded.

Fig. 1. Videogame screenshot

2.1 Editor Sections

The editor has seven main sections for the creation of a videogame: Introduction, concept definition, diagnostic evaluation, selection of main characters, script definition, game over, and the export for download to the mobile device.

The Script Definition section is the main section of the editor (see Fig. 2). It allows the teacher to create a graph based on a concept map, and to provide each node with a position over the game map. It also allows the user to define the characters that will represent each of the concepts in the game, and to configure their particular properties and characteristics. This section includes the following main elements: (i) Start Node corresponds to the most inclusive concept on the concept map, which implies the most general concept. It is the starting point for the videogame. (ii) Node corresponds to any concept on the concept map, besides the most inclusive (start node). Teachers add nodes to the videogame, and these nodes have various associated properties (name, welcome text, question, answer choices, etc.). There can be two different kinds of nodes. A multiple-choice question node presents the player with a question and three possible answer choices. On the other hand, an item question node presents the player with a question that asks him to find one of three items that are dispersed throughout the map. (iii) End Node is the ending point of the game and does not correspond to any concept on the concept map.

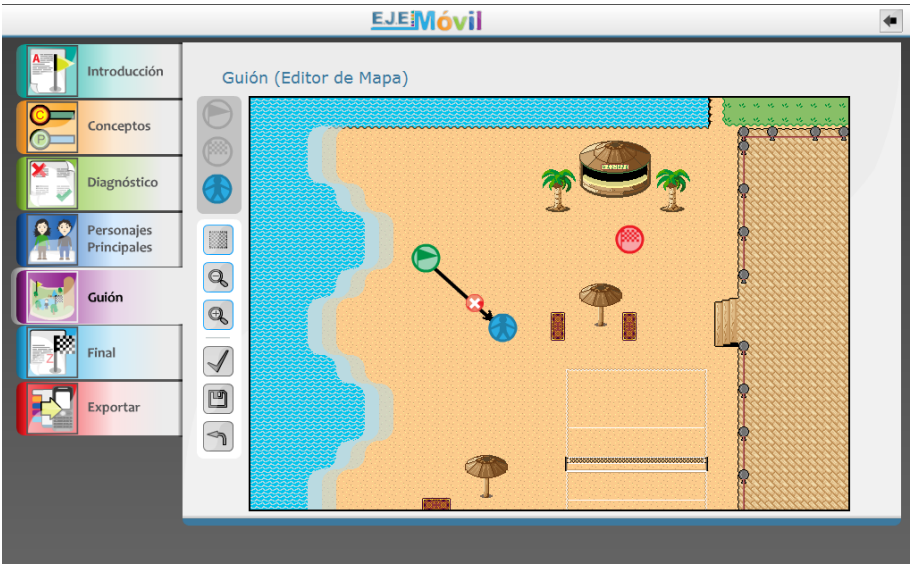

Fig. 2. The Script Definition section

2.2 Design Technique for Videogames

A concept map can be used as a road map to show some of the pathways that are available for connecting the meanings of concepts through the use of proposed concepts [7, 13]. The idea of using concept maps as a way to design serious videogames has emerged from this line of thinking.

A graph satisfies the properties of a concept map. Concept maps are hierarchical, with the more inclusive concepts located up high and the less inclusive concepts located below [7]. The absolute hierarchy of a node corresponds to the number of nodes that there are between the end node and the original node.

Another point to keep in mind is that graphs do not support edges composed of more than two nodes like the one shown in Figure 3.a. In order to deal with this problem, relationships on a concept map that link three or more concepts (N concepts) through one linking word need to be accommodated, as shown in Figure 3.b, linking the concepts through N – 1 linking words (Transformation 1).

Another characteristic from concept maps that is supported by the graph representation proposed is cross-links, which are relationships between concepts within different domains of a concept map. In order to represent the cross-links, an additional step is required (Transformation 2). For a cross-link from concept C1 to concept C2, a new concept needs to be added, concept C2'. Concept C2' has the same name as concept C2 and a link from C1 to C2' needs to be made. The original cross-link from concept C1 to C2 is then deleted. New links need to be made from concept C2' to each of the concepts to which concept C2 is linked (See Figure 4).

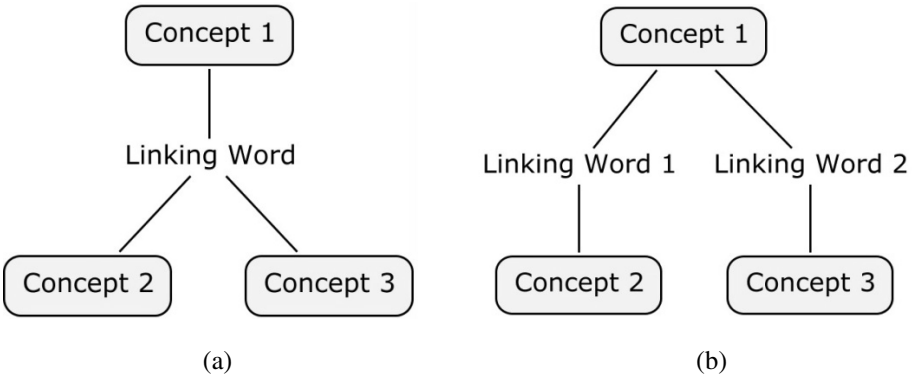

Fig. 3. (a) Relationship between three concepts on a Concept Map. (b) Transformation 1 required by the editor.

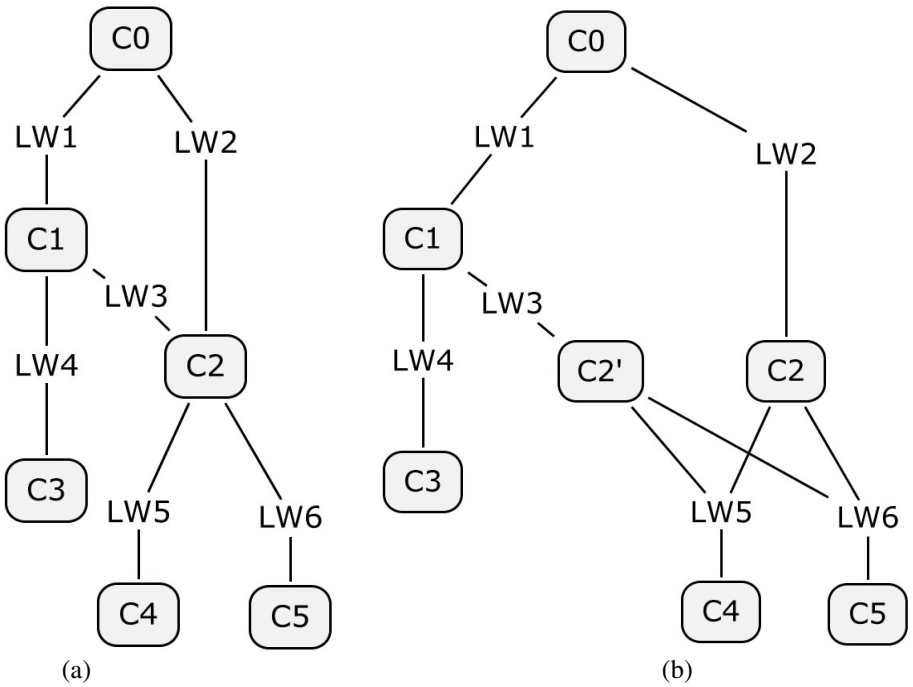

Fig. 4. (a) Cross-link between concept C1 and concept C2 on a Concept Map. (b) Transformation 2 required by the editor.

The proposed technique for videogame design consists of the following steps: (i) Checking whether the conditions necessary to perform transformations 1 and 2 have been met, and performing the desired transformations if possible. (ii) For each concept on the concept map, add a node (character) to represent it on the videogame screen map. (iii) For each relation that connects two concepts, add an arrow between

the two nodes that represent the concepts. (iv) For the properties of each node, form a question using the highest-order concept (or concepts) that are directly related to the concept that is represented by the node, together with a connecting phrase (connector) describing the relation. (v) In the properties of each node, use the concept that the node represents as the correct answer to the question that the character presents to the player.

3 Videogame Design Evaluation

A preliminary evaluation was performed in order to evaluate the proposed design methodology, to determine if the creation of a videogame from a concept map is appropriate and easy enough for a teacher to do. It was also important in order to learn what the teachers thought of the methodology in pedagogical terms, or if they believed that the game is able to convey successfully the information contained in the concept map to the students, making it possible to understand the hierarchies and relations between the concepts.

3.1 Participants

A group of 13 participants was tested, all of which were in-service teachers. Five of these users were male and the other eight were female. All of the participants had experience with concept maps; one of them said he rarely uses them with his students, six of them said they normally use them, five of them frequently use them and one of the participants reported that he always uses concept maps with his students. All of the participants use computers daily, and nine of them had previously used concept map related software. Two facilitators also participated assisting the participants.

3.2 Instruments

In order to evaluate the methodology proposed, a questionnaire divided into two sections was used. In the first section, 9 statements were presented to the users together with a 5-level answering scale (strongly disagree, disagree, neither agree nor disagree, agree, strongly agree) to each statement: (1) It is simple to transfer the concept map (CM) to the game. (2) Transferring the concept map to the game is fast. (3) There is no loss of information when transferring the concept map to the game. (4) It is simple to incorporate the concepts from the concept map into the game. (5) It is simple to incorporate the relations and hierarchies from the concept map into the game. (6) It is simple to incorporate the proposals from the concept map into the game. (7) The end result coincides conceptually with the desired result. (8) I have successfully created a concept map-based game. (9) The proposals are well represented in the game through the dependencies defined in the editor.

In the second section, users were presented with 5 open-ended questions: “What did you like about this methodology?”, “What did you not like about this methodology?”, “What would you add to this methodology?”, “What do you think you could use

this methodology for?", and "What do you think about the result?" For these open-ended questions, the users were asked to write answers as long as they wanted. Also, an additional space was provided to allow the users to express any situation or opinion that they considered to be significant, and which they felt had been left out of the questionnaire.

3.3 Procedure

The first step was to explain the activity to the users. This was followed by an explanation of the methodology that would be used to create a concept map-based videogame, which was explained to each user individually. Afterwards, each user was provided with a pre-established concept map, based on the concept of the atom, and was asked to create a videogame based on this map using the editor. In order to standardize the evaluation, the users were not allowed to modify the structure of the pre-established concept map. The facilitators observed the entire process of the creation of the videogame, and took note of any relevant situations observed or that were mentioned by the user. In addition, a screen recorder was used to record the entire process. During the evaluation, the facilitators did not answer any questions asked by the participants regarding the creation of the videogame, in order to avoid contaminating the data collected. However, exceptions were made when the users were clearly stuck with something, and when the questions were related to the interface. Once the user had finished creating the videogame, they were given the evaluative questionnaire to fill out in order to capture their immediate impressions and opinions concerning the proposed methodology.

3.4 Results

The results are promising. Each statement obtained an average score of over 4.0 points out of a total of 5 possible points, which means that the users mostly agree with the statements (see Fig. 5). The most poorly evaluated statement is related to the speed with which the users were able to create a videogame from a concept map. The average result obtained for this statement was 4.08, which means that the users were barely in agreement with the statement (2). Despite this score, it is relevant to point out that 3 of the 13 users assigned a score of 2 to this statement (disagree), and 7 users assigned a score of 5 (strongly agree). The low result obtained, in comparison with the other statements, is not directly related to the methodology itself, but rather with the high number of properties that must be defined in the editor in order to create a videogame that is of interest to a player. The definition of the game includes 15 concepts, which mean the users had to fill in the properties of 15 different characters in the videogame.

The two most relevant statements regarding the methodology are: statement 1, and statement 3. These statements provide an idea of what can be achieved with the editor in pedagogical terms. The results obtained for each of these statements were 4.6 and 4.7, respectively, on a possible scale of 1 to 5. These scores are further corroborated by the users' comments that the videogame created conveys the information from the

given concept maps satisfactorily. The users also stated that they believe that the students would be able to perceive the concepts and relations in the videogame's underlying concept map. The lowest score attributed to statement (1) was 4.0 (agree), while the lowest score assigned to statement (3) was 3.0 (neutral). However, only one user attributed this score, and all the rest either agreed or strongly agreed with this statement.

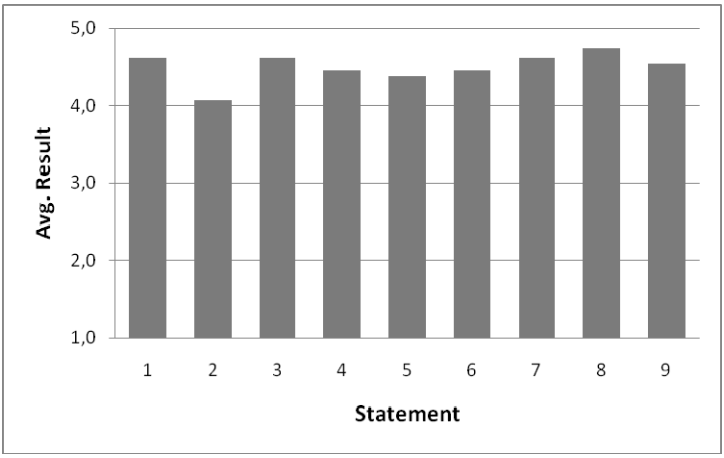

Fig. 5. Results from the methodology evaluation

The statements 4, 5, and 6 represent a disaggregate of statement 1. They are centered on each of the individual elements of a concept map independently. The results obtained from these statements strengthen the result obtained from statement 1. The result from statement 4 was an average score of 4.46, for statement 5 the average score was 4.38, and statement 6 presented an average score of 4.46.

One aspect that was commented on by most of the users is that they would have liked to see the videogame that they had recently created run on their mobile phones. However, this was not possible due to the fact that at the time of the evaluation only a very preliminary version of the videogame engine was used, which did not include appropriate graphics, and for which reason users could have felt somewhat disappointed with the result. They also mentioned that they would like for the students to create the videogames, based on a concept map, by using the editor.

4 Conclusions

In this study we present and evaluate a new technique through the use of concept maps for the design of serious videogames using Ejemovil Editor. The evaluation of the methodology is preliminary and a future full evaluation is needed that incorporates the students playing the videogame created by using the proposed methodology to determine the cognitive impact of the application. However, in the meanwhile it

can be pointed out that the perception of the end users regarding the methodology was satisfactory.

All of the users agreed that the transfer from the concept map to the videogame is natural, the validity of which was corroborated by observing the results obtained from the questions regarding the same aspect, but differentiating between the varying elements of a concept map. This is a significant result, as it implies that the users had no problems understanding and applying the proposed methodology. As was previously mentioned, teachers are generally reluctant to incorporate new technologies into the classroom, for which reason having a methodology that is natural for them to use is an important advantage when developing a tool that is oriented towards use by teachers. All of the research subjects mentioned that the editor could be a useful tool for teaching. Some pointed out that it would be useful in order to introduce the subject of a new educational unit, while others mentioned that it would be more useful after a unit had been entirely taught, in order to help students to review the most important concepts and the relationships between them.

The evaluation provides initial data that indicate that the proposed methodology is accepted by end users and could be appropriate and easy to use in the design and creation of serious, educational videogames. This is mainly because it incorporates a conceptually organized and hierarchical way to present concepts, and because it is simple and natural to use. Finally, a wider-ranging evaluation regarding the design methodology presented is needed in order to verify and corroborate that it is understandable and easy for teachers to use. The following step is to design an evaluation that includes students playing the videogame created by teachers using the same methodology, in order to determine if they are able to make cognitive progress by playing the game.

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