Teachers Can Be Involved in the Design of Location-based Learning Games

The Use of the Puzzle Board Metaphor

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Abstract: Recent research in the Game-Based Learning domain shows that location-based games can lead to positive effects in students' motivation and engagement. However, the potential effectiveness of these approaches depends on to what extent their design is aligned with the requirements of specific educational situations. For this reason, involving teachers in the design of their own location-based learning games becomes crucial to fulfil their teaching requirements. This paper presents a metaphor based on puzzle boards as a technique to involve teachers in the design of their own location-based games. A design-based research methodology has been followed to evaluate the proposed metaphor. Previous research experiments have shown the feasibility of the puzzle-based games approach to allow secondary education teachers the design of these types of learning experiences. However, some issues in terms of understanding specific elements of the proposed metaphor were detected. A second iteration of the research methodology is described in the paper to evaluate the changes made to the definitions of the metaphor's elements and the dynamics of the game design task. The evaluation is carried out with 20 primary and secondary education teachers who completed a paper-based design task. The main findings show that teachers did not have problems using the proposed metaphor and they successfully designed their own location-based learning games.

1 INTRODUCTION

Over the past few years, handle devices have enabled learning situations that were hindered in the past by time and spatial limitations (Jones and Jo, 2004). These mobile technologies have brought the possibility to enhance learning and promote the creation of situated learning activities. In fact, mobile learning (m-learning) is an emerging field of educational research that is starting to attract the interest of practitioners in all phases of education to facilitate learning in informal settings within formal educational contexts (Bachmair et al., 2010). Most of these m-learning activities are characterised by integrating elements based on games (Bohannon, 2010). This leads to the creation of location-based games (Davis, 2002), based on mobile technology to implement pervasive and ubiquitous experiences.

Location-based games bring opportunities to: create learning experiences that involve exploration and cooperation (Hwang et al., 2008); access to contextualized information, communication, analysis and interrelation of real place (Roschelle, 2003); entertain and increase students' motivation towards learning (Davis, 2002; Yatani, 2004).

In order to create meaningful location-based learning games, it is important that they are aligned with the requirements of specific educational situations. In this line, it becomes crucial to involve teachers in the design of game-based learning activities (Tornero et al., 2010). However, teachers are faced with the difficulty to set these approaches so they fit into the educational process and the accomplishment of the pursued learning objectives (Tornero et al., 2010; van Rosmalen et al., 2011). Besides, the support by teachers is not straightforward, and the limited experience of teachers severely reduces the amount and quality of feedback a learner might receive. In this line, providing scaffolding strategies could be significant to foster the involvement of teachers in the design and implementation of their own location-based learning games. In general, scaffolding techniques involve different type of processes (e.g.: coaching

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through prompts, templates, guides or strategies) that teachers implement to support students in problem solving activities whose goals would be beyond their unassisted efforts (Wood et al., 1976). Particularly, this paper focuses on providing a strategy that could scaffold teachers in the design process of their own location-based learning games.

With the aim of facilitating teachers in the design of location-based learning games, a metaphor based on puzzle boards has been proposed (Melero et al., 2013). The metaphor simplifies a model for designing computing-supported puzzle-based games (Melero & Hernández-Leo, accepted). In this context, metaphors have been widely used as well-known concepts that facilitate reasoning about design in unfamiliar contexts (Lakoff, 1993). Besides, the use of puzzle game boards seem to offer a strategy to feasibly involve participants as game designers (Huang et al., 2007). Also, the structural design of location-based games is often inspired by board games (Nicklas, 2001; Schlieder et al., 2006). However, there are not research evidences on involving teachers in the design of location-based learning games considering puzzle game boards as a design strategy.

The originality of this paper relies on considering elements of traditional puzzle boards as a design technique to create location-based games. The remainder of the paper is structured as follows. Section 2 presents an overview of the proposed approach to design location-based games. Section 3 describes the research methodology to evaluate the puzzle board metaphor. Section 4 describes the workshop in which the teachers used the proposed metaphor to design their own location-based games. The main findings obtained from the analysis of the teachers' opinions and designs are reported in Section 5. Then, Section 6 is devoted to a discussion of the findings presented in this paper. Finally, Section 7 concludes with the main highlights obtained from the results and future research lines.

2 THE PUZZLE BOARD METAPHOR

A puzzle board metaphor has been proposed (Melero et al., 2013) as a design technique to facilitate teachers the creation of location-based games. This metaphor considers a conceptual model for creating computer-supported puzzle-based games (Melero and Hernández-Leo, accepted). An exploratory user study involving teachers from secondary and higher education were also described in (Melero and Hernández-Leo, accepted). Some of the findings revealed the need of providing a strategy to support teachers the creation of devoted environments.

Then, the aim of the proposed metaphor is to facilitate teachers the design of location-based learning games that are mainly characterised by containing routes of geolocated questions. As described in (Bontchev and Vassileva, 2010), these games consist in presenting quizzes in map where knowledge from course material is taught in a safe navigation.

In order to design location-based games of geolocated questions, the puzzle board metaphor considers the following elements (see Figure 1):

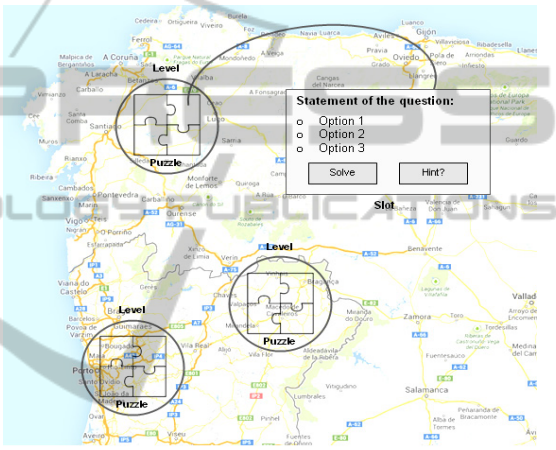

Figure 1: Representation of the puzzle board metaphor.

- The "board" is the physical space where the questions are located.
- The "slots" are the different questions, while the "pieces" are the options associated to a question. Just one "piece" can fit in a concrete "slot", meaning that there is only a correct option for each question.
- A "board" with a set of "slots" and the associated "pieces" forms the "puzzle".
- Several "puzzles" can be defined in a location-based learning game. Each puzzle has to be associated to a "level". A designer can define as different "levels" as he/she wants.
- Several "scoring" mechanisms can be defined to reflect the students' performance: a) correct answers add points to the overall player's score, b) incorrect answers subtract points the overall player's score, and c) consulting hints subtract points the overall player's score.
- Scoring can have associated a "feedback" to specific range of points in order to describe to the students their performance.

- An extra "bonus" of points can be also designed whether all the questions for a given level have been correctly answered. The extra bonus is a reward to engage and encourage students to correctly complete the different puzzles of the whole learning activity.
- Finally, "hints" can be provided in order to avoid frustrations and advance forward the location-based learning game.

3 METHODOLOGY

A design-based research (Barab and Squire, 2004) methodology has been followed to evaluate the puzzle board metaphor. Overall, this research methodology involves a continuous cycle of design, enactment, analysis, and redesign. The cycle of this research methodology involves revisions to test and refine a proposed innovative learning approach. This iterative process permits not only to validate the findings of the analysis phase, but also to reflect on how these findings alter the outcomes of the other phases (Barab and Squire, 2004).

A first iteration involved four experiments with 11 secondary education teachers that became designers of their own location-based games. The first iteration has reported the feasibility of applying the proposed approach in real learning contexts (Melero et al., 2013; Melero and Hernández-Leo, accepted). Besides, the resulted designs of the location-based learning games were implemented in "QuesTInSitu: The Game", a mobile aplication compliant with the conceptual model presented in (Melero and Hernández-Leo, accepted). In concrete, the four experiments consisted of: a) an extracurricular activity with the purpose of discovering and learning about the city where the school is placed; b) an activity associated to formatively assess their students in the art history of a city; c) an activity also with the aim of enquiring about the heritage and the city where the school is located; and d) an activity to practise the concepts associated to different pictures of a museum of contemporary art. Results showed that the different teachers were able to design their own activities, but some issues were detected: 1) a need of devoting more time in the explanation and provision of more examples in relation to the puzzle board metaphor; and 2) a reformulation in the definition of the "level" element, indicating that it may typically refer to specific physical zones or geographical areas (not only difficulty).

Thus, this paper presents a second iteration of the research methodology to gain more insights about the use of the puzzle board metaphor. To this end, a workshop session was conducted involving 20 primary and secondary education teachers in a game design task. The aim was to evaluate some changes taking into account the aforementioned considerations. The evaluation was focused on analysing the acceptance of the proposed puzzle board metaphor by the teachers, and the feasibility of using this approach to create location-based games for different educational purposes and education levels (not only secondary education, as in the first iteration).

4 GAME DESIGN PROCESS

A 4-hour workshop was carried out to evaluate the puzzle board metaphor with different teachers. Upon an open call for participation via the network for educational telematics of Catalonia (http:// www.xtec.cat), 20 primary and secondary education teachers from different schools and not familiar with designing location-based games participated in the workshop. The session was divided as follows:

- Introduction (30 min). First, we introduced the context of the workshop focused on designing location-based games. Then, we present the proposed metaphor and a description of the different elements involved in the metaphor. Several examples of using the metaphor in real learning contexts (e.g. Melero et al., 2013) were also described in order to facilitate the teachers' comprehension of the proposed approach.
- 1st Questionnaire (15 min). The teachers were asked to fill a questionnaire concerning the different aspects presented before. In concrete, we asked them to: a) give an opinion about the perceived benefits of using the puzzle board metaphor; b) rate the importance of the elements involved in the metaphor, and the difficulties understanding these elements; and c) highlight the aspects that (positively or negatively) caught their attention.
- Game design task (60 min). The teachers were engaged in designing a location-based game meaningful to their particular teaching practices. In this sense, we encouraged teachers to think about an activity relevant to their teaching practices and provided the teachers with a set of templates (see Figure 2), conforming the proposed puzzle board metaphor. These templates aim to facilitate the design of the structure and content of their location-based

learning games.

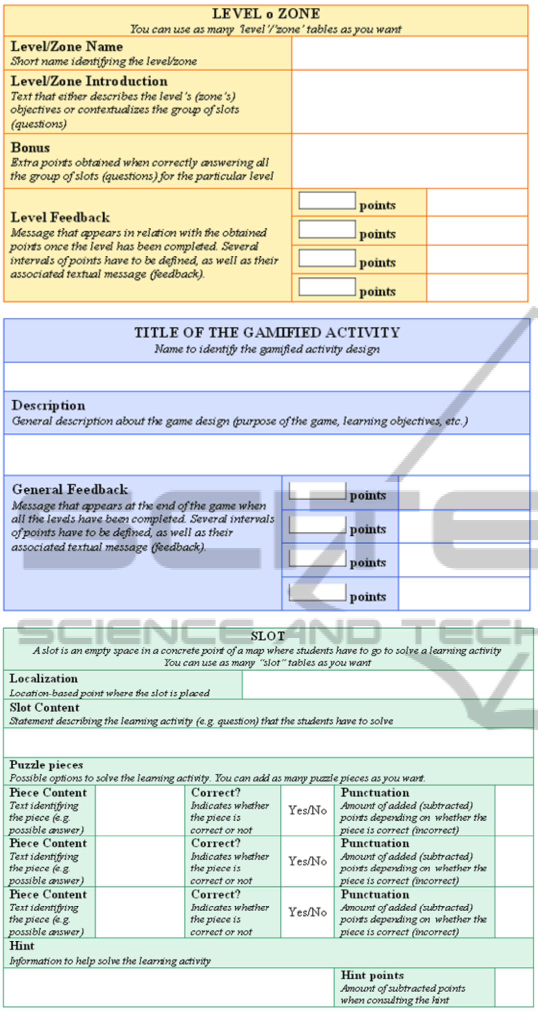

Figure 2: Templates for game designing.

- 2nd Questionnaire (15 min). After finishing the game design task, each teacher filled out a second questionnaire about the following items: a) whether the use of the templates constrain the design of the game or not; b) the understanding of the different elements of the templates; and c) the steps followed to design the location-based learning game.
- Test a demo game (45 min). The teachers, using their own smartphones, were able to test a mobile application demo using "QuesTInSitu: The Game" (see Figure 3). The demo contained 2 levels, and 3 multiple-choice questions per level about different locations near the place of the workshop.
- Discussion group (45 min). Finally, a discussion group with the teachers was carried out to share the main impressions about the proposed metaphor and the templates.

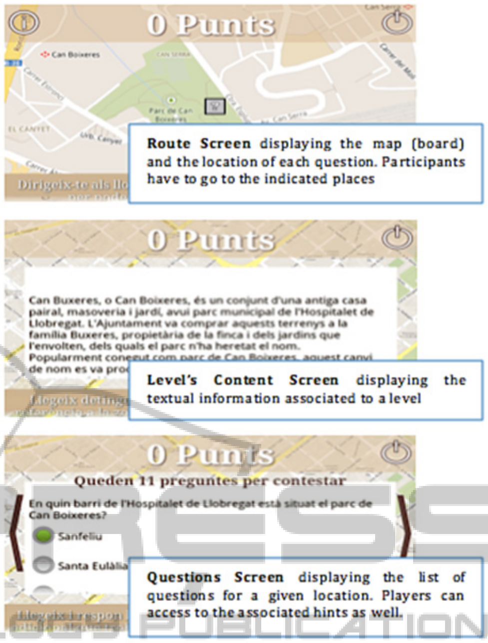

Figure 3: Some screenshots of the mobile application.

5 EVALUATION

A mixed method has been followed (Cairns and Cox, 2008) including several data sources (see Table 1) to evaluate different aspects of the proposed metaphor and the teachers' game designs. The obtained qualitative and quantitative gathered data have been contrasted and triangulated (Guba, 1981). Quantitative data, obtained from the ratings given by the teachers in the questionnaires, provide insights into teachers' acceptance about the metaphor. This obtained information will be supported or rejected by the qualitative data (Guba, 1981).

Table 1: Data gathering techniques.

Data source	Type of data	Label
First Questionnaire	Quantitative ratings and qualitative opinions by the different participants	[1st-Quest-X] Where X is the number of the participant, from 1 to 20.
Second Questionnaire	Quantitative ratings and qualitative opinions by the different participants	[2nd-Quest-Y] Where Y is the number of the participant, from 1 to 13.
Game Designs	Paper-based templates that capture the game designs	[Design-Y] Where Y is the number assigned to a design, from 1 to 11.
Observations	Record of direct observations taken during the discussion group	[Observation]

5.1 Resulted Designs

The teachers were provided with a set of templates (Figure 2) intended to allow them to design a location-based learning game formed by 2 levels and 6 questions. 7 teachers did not get involved in the game design tasks. Some of them left the room because of personal matters, and others because they expected to use an authoring tool to perform the task: "*I think it would be more interesting to use the application*" [1st-Quest -15], "*Disappointed to not could use the authoring tool*" [1st-Quest -19].

11 designs resulted from this task. 9 participants individually designed their own location-based game, while 4 worked in pairs. 3 of these games were designed for primary education [Design-2-6-7], 6 for secondary education [Design-1-3-5-8-10-11], and 2 designs did not specify the educational level [Design-4-9]. Besides, these m-learning activities were designed for different subject matters: natural science [Design-1-7], multidisciplinary activity (physical education, technology, etc.) [Design-2-3-4-9], arts [Design-5-11], literature [Design-6], technology [Design-8], and social science [Design-10].

The purpose of each design was: an activity about Olot's volcanos [Design-1]; a walking tour in Barcelona to discover different monuments [Design-2]; an activity for discovering the city of El Prat [Design-3]; a gymkhana in Ripoll's river [Design-4]; an activity in the school yard about several well-known design objects [Design-5]; a learning route about the streets of Sabadell named with popular poets names [Design-6]; a situated activity in the Zoo of Barcelona about wild animals [Design-7]; a learning activity about structures, types, and functionalities, history of different buildings and/or materials [Design-8]; an activity about the recognition of certain landscape features near the high school [Design-9]; a route for different economic institutions [Design-10]; an activity about modernist buildings in Barcelona [Design-11].

Teachers followed different approaches to design the content of the different levels. In concrete, the information of the levels was designed as a description of the geographical zone in which the questions are located [Design-1-2-7], as a textual information about the content of the questions [Design-5-8], or as instructions about the dynamics of the game for the particular level [Design-4-9-11]. The rest of participants [Design-3-6-10] did not fill out the information associated to levels' content.

Paying attention to the hints, 9 out of the 11 designs included hints as additional information about the statement of the questions [Design-1-3-4-5-6-7-8-9-11]. Only 1 participant used the hints' content to indicate physical places to find useful information [Design-2].

About the design of scoring mechanisms two approaches were followed: one more oriented to traditional tests (e.g. 1 point correct answers, -0.3 points incorrect answers) [Design-3-11], and other more oriented to games (e.g. 100 or 50 points correct answers, 50 or 10 points incorrect answers) [Design-1-2-4-5-6-7-8-9-10]. Besides, different bonus strategies were followed: adding the same amount of points as correct answers [Design-3-4-5-7-11], adding higher amount of points than correct answers [Design-8-10], and adding lower amount of points than correct answers [Design-1-5-9]. Furthermore, considering the design of points when accessing the hints, some participants chose to subtract: the same points as incorrect answers [Design-1-5], higher points than incorrect answers [Design-3-7], and lower points than incorrect answers [Design-2-4-8-9-10-11].

5.2 Results on the Proposed Metaphor

In general, the teachers had no problems understanding the different elements involved in the proposed metaphor. Specifically, all the teachers quite or totally agreed that they did not have problems understanding the role of "slots", "bonus points", "hints", and "feedback" associated to the completeness of a level and the whole game. Also, 19 out of the 20 teachers quite or totally agreed that they understood the meaning of a "level" and a "puzzle piece". However, one of the teachers said, "*I think it is difficult to implement this approach in Primary Education. I should have played the game before trying to do my own design to know how to apply this approach in my teaching practices*" [1st-Quest-14]. But, as other of the teachers indicated "*I think this approach could be perfectly implemented in primary education. Besides, it is a good approach to interpret maps and put in practice orientation skills*" [Observation].

Paying attention to the definitions of each element involved in the metaphor the results were as follows. 14 out of the 20 quite or totally agreed on the definition of allowing students to solve each question as many times as needed. But, after the game design task, some teachers pointed out that the number of trials to solve a question should have a maximun attempt limit: "*The questions should not be answered indefinitely. Otherwise, the students could do trial and error*" [1st-Quest-3-4], "*I would*

set up a maximum number of attempts" [1st-Quest-13], "*if students have a limit amount of attempts to solve the questions, I think they would pay more attention*" [Observation]. However, each element involved in the metaphor should not be seen as a standalone item as agreed in the discussion group: "*in order to make a right use of attempts when answering the different questions (to avoid trial and error), the scoring should be designed accordingly*" [Observation]. Besides, all the teachers totally agreed that the hints allow guiding the students to find the correct answers. However, two thirds of the teachers (15/ 20) indicated that hints should be designed in those cases that were relevant. Otherwise, designing hints could become a tough task: "*we did not design hints to motivate more the exploration*" [Observation], "*I have problems to define hints that were not obvious*" [Observation]. 17 out of the 20 teachers quite or totally agreed that bonus points are a good mechanism to motivate students. Also, almost all the teachers (19/20) quite or totally agreed on the importance of providing feedback and adapted scores depending on the number of attempts when solving questions. Furthermore, 18 out of the 20 teachers quite or totally agreed that the points and feedbacks are good approaches to reflect the correct and incorrect students' actions. Some comments were: "*Feedback is indispensable when learning*" [1st-Quest-17]. However, some difficulties arosed: "*I found difficult to design the intervals for the scoring mechanisms*" [2nd-Quest-13], "*I think higher points, similar to games (such as tetris), would engage more the students in the learning activity task*" [Observation], "*I had to be very careful with the different amount of points to design a meaningful activity*" [Observation], and "*I was not sure about the amount of points to define as bonus*" [Observation]. These results indicate that despite the elements involved in the metaphor are understandable, in some cases (e.g. desining scores), it is necessary to provide teachers with recommendations to their concrete requirements.

5.3 Results on the Use of Templates

Once the teachers finished the game design task, they filled out a questionnaire intended to gather major impressions about the metaphor and use of the templates in the design task. Concerning the question "Will you find useful the metaphor to create your own location-based game?", all the 13 teachers agreed that they would use the proposed approach. Some comments were: "*This approach could be implemented in different subject topics of mine*" [2nd-Quest-9], and "*I would definitely use this approach to design punctual activities such as field trips*" [2nd-Quest-3]. The teachers also highlighted several educational benefits: puzzle board metaphor was considered a motivating approach [2nd-Quest-2-3-13] that could encourage students to outperforming themselves [2nd-Quest-4], promote learning in groups [2nd-Quest-5-7-8-12], and engage students to become more active [2nd-Quest-5-10].

When asking the teachers about the use of paper-based templates, all the teachers considered the templates a useful approach to structure the design of their location-based games. Some comments were: "*the templates help to structure the information*" [2nd-Quest-7], "*[…] to structure the whole game*" [2nd-Quest-3], and "*I understood all the elements*" [2nd-Quest-11]. Also, most of the teachers quite or totally agreed on the user-friendliness of the templates for designing the levels (9/13), slots (9/13), puzzle pieces (10/13), scoring (10/13), hints (9/13), and feedbacks (9/13).

Finally, we asked the teachers to order a list of actions according to their process when designing the location-based game: a) fill the information according to the both game's title and description; b) indicate the level's (zone's) name and description; c) define the level's scoring and feedback; d) specify the slot's description; e) define the hint associated to a slot; f) define the overall scoring and feedback of the game; g) define the bonus associated to a level; h) indicate the localization of the slots; i) define the points associated to the slot's answers; and j) define the points associated to the hints. In this line, all the participants started defining the game's name and its description, followed by the level's name and its description as well. But after this, participants followed different paths for designing their games. For instance, some of them continued their design process by defining the slot's description [2nd-Quest-2-5-7-8-13] and others by indicating the localization of the slots [2nd-Quest-3-10-11-12].

6 DISCUSSION

Over the past years, some research efforts have been done towards supporting teachers in the creation of game-based learning environments. However, the implementation of this type of environments has not been as broadly adopted as one could has expected. Most of tools have reported problems, such as, hard to adapt to specific teaching practices, requiring too many resources and too much time for development.

Thus, focusing on location-based games, it seems relevant to provide teachers with approaches that facilitate the design of this type of m-learning activities to their specific educational situations.

We believe that proposing a metaphor could be relevant to facilitate and guide teachers in the design of their own location-based games. The reason of using a metaphor can be significant to present a familiar context to the teachers in order to facilitate the comprehension of the game design task. Using puzzles boards becomes relevant in this context because these are well-known games used in educational context. Besides, board games in general has been already considered to be mapped as location-based games. Then, the proposed metaphor could be a potential approach to scaffold teachers in the design of their own location-based games.

The puzzle board metaphor has been proved a suitable approach to design location-based games. Previous experiments, despite of some misunderstandings, have reported the feasibility of designing and enacting location-based learning games for secondary education. Teachers perceived the proposed approach relevant to their teaching practices. Besides, the enactment with secondary education students revealed that the proposed approach promoted students being more active when solving the designed questions. Specifically, students tried to avoid losing points by paying more attention to elements of the physical place, asking people and searching the Internet. Further research was needed to analyse a second iteration of the metaphor in different educational levels. This second iteration, presented in this paper, has reported that elements involved in the puzzle board metaphor were properly understood. Different location-based game designs for primary and secondary education resulted from the task. Besides, participants were able to design their location-based games according to their specific requirements.

Furthermore, paper-based templates have been proved to be a good approach to put into real practice the proposed metaphor. The templates has been useful to structure the content of the designed location-based games. Also, this paper-based approach gives insights towards the design and the development of an authoring tool compliant with the puzzle board metaphor. In this context, the authoring tool has to be flexible enough to allow teachers to follow different paths when desining their own location-based games.

When designing location-based learning games it is important to consider the effects of design decisions in concrete elements will have on the rest; the different elements involved when designing this type of activities should not be treated in isolation. For instance, the design of the scoring mechanisms could influence on answering questions or accessing to the hints. Besides, results have shown that it would be advisable to provide recomandations to the teachers about scoring mechanisms. Different strategies can be followed to design diverse types of scoring mechanisms: adding/subtracting higher amount of points (e.g. 100 points correct answers, -50 points incorrect answers) versus following a more traditional assessment approach (e.g. 1 point correct answers, -0.3 points incorrect answers). Thus, it seems relevant to integrate some kind of guidance for teachers that recommends which scoring strategy follow considering his/her educational needs.

7 CONCLUSIONS

This paper has described a strategy based on a puzzle board metaphor to facilitate teachers the design of their own location-based learning games. Particularly, in the frame of a design-based research methodology, the paper presents a second iteration in the formulation of the metaphor and the associated design process. The evaluation of the iterated approach focused on analysing the changes performed in the definition of the "level" element and the dynamic of the game design task. Results have shown that teachers have properly understood the proposed approach and highlighted many educational benefits. The great majority of teachers agreed with the definitions of the different elements involved in the proposed metaphor. Besides, participants become aware of the importance of not considering the elements of the metaphor as isolated items. Designing appropriate scores could influence in avoiding trial and error.

The puzzle board metaphor has been proved also to be a feasible approach to define location-based games for different contexts and educational purposes. Besides, the use of paper-based templates have been positively valued for structuring the content of the activities, as well as for flexibly designing these m-learning activities.

As a whole, teachers positively adopted the proposed approach and sought for an authoring tool. In this line, results obtained in the evaluation have provided insights to further work in the implementation of an authoring tool that allows the creation of location-based games. Results obtained in the design process indicate that teachers follow different paths when designing their own location-

based learning game. This suggests that the authoring tool should not enforce a guided process. Instead, the tool should provide enough freedom to allow the teachers to follow their own desired path to create their location-based games. Besides, one of the findings is about the dificulties when designing adapted scores because teachers are not sure which would be the better approach to follow. Implementing recommendations in an authoring tool to facilitate this task is one aspect that requires further research.

Finally, a follow-up experiment with teachers who attended the workshop would be relevant to evaluate more deeply the usefulness of the proposed approach. Previous real experiments have proved the feasibility of implementing location-based learning games for secondary education using the paper-based templates. However, this study has presented designs in other educational levels and subject topics that could be worthwhile to implement in order to evaluate the impact of using the proposed approach.

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