Exploring Context-Aware Activities to Enhance the Learning Experience

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Abstract. Mobile geolocation applications have been growing in popularity in the last decade. The ability to run a service on a mobile device that provides facts or recreational information to users opens up new opportunities to create engaging learning contexts. However, the potential of such services has not been fully exploited within educational settings, as compiling functional, student-friendly, context-aware learning journeys required advanced programming skills. The authors discuss this challenge and present tools that facilitate the construction of gamified learning paths, which integrate context-aware activities and minigames as motivational drivers for learning. The paper reports on the user testing feedback obtained in workshop settings.

Keywords: Authoring tools · Learning path · STEM · Minigames
Beacons · QR codes · GPS · Learning experiences

1 Introduction

Technology-based innovation brings forth new opportunities to construct engaging and motivating learning journeys [1]. Context-aware services, in particular, provide means to expand the learning experiences outside of the classroom and produce learning

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contexts that immerse students. By using beacons, a class of Bluetooth low energy devices that broadcast their identifier to smartphones, tablets and other devices to perform actions when in close proximity to them, teachers are able to model flexible and transformative learning sequences that provoke students to learn through exploration [2]. While digital games have been successfully used to engage students [3–6], context-aware learning activities provide a new approach, which takes advantage of context, place, and time of use, enabling teachers to increase the immersion level of learning.

Context-aware services represent a cost-effective solution that enables the implementation of agile and flexible teaching strategies that answer to the highly dynamic expectations of the new generations and support participation [7, 8]. However, it is necessary to empower the teachers with user-friendly tools that do not require advanced programming skills.

The paper addresses these challenges and presents a context-aware tool that interconnects with an Authoring Tool for Gamified Lesson Paths (AT-GLP) and a Metagame Runtime that are part of a pervasive learning platform. Together they enable the designing of innovative, game-based learning processes, which addresses the student expectations and have a great impact on the effectiveness of individual/group learning. These tools allow the designers to contextualize and build new context-based activity scenarios for implementation in a lesson path adapted to the different needs of its users (i.e. student and teachers). The paper outlines challenges and architecture of the Context-aware authoring system before it presents some of the minigames and finally details the feedback from the first usage in a workshop and lessons learned.

2 Authoring Context-Aware Activities

A set of tools has been developed in order to facilitate the construction of location-based learning systems that aim to engage students through new experiences that motivate learning. This section presents the architecture and functionalities of these tools. Learning Experiences (LEX) created using the Authoring Tool for Context-aware Challenges (ATCC) are reusable and customizable and their purpose can be changed. Teachers and learning designers are able to reuse existing LEX or their own, just personalizing basic parameters. This gives them the possibility to change the number and places of the locations to visit, customize the difficulty level or change the pedagogical content to fit the context-based activity to new lesson plans in a quite easy way, without programming skills.

2.1 The ATCC Architecture

An Authoring Tool for Context-aware Challenges (ATCC) has been developed in order to enable teachers to create gamified learning paths. The ATCC consists of three main components:

- The configuration tool for the Context-aware Challenges
- The Beacons inventory
- The Adobe Air Native Extensions (ANE) Extension

These components act as capability builders, enabling teachers to create playful location-based experiences. The ATCC uses three position tracking technologies: beacons, GPS, and Quick Response (QR) Code.

The ATCC communicates directly with the Authoring Tool for Gamified Lesson Path (AT-GLP). The ATCC serves as the main tool for context-aware learning activities and allows teachers to setup specific parameters of the experience. To complement ATCC, a Beacon Inventory was developed to store beacons and QR codes. It also helps teachers manage the position tracking technologies and assigning them to proper classes and groups. The Metagame Runtime is a customizable context-based activity environment that incorporates all the learning activities from a Gamified Lesson Path (GLP) in a game narrative. The Metagame Runtime is developed in AdobeAIR and requires the ANE native plugin in order to interact at low level with the device's functionalities transmitting position information from beacons to the Metagame application. Students access the Metagame to play the activities, including minigames, defined by the AT-GLP and the ATCC.

The diagram in Fig. 1 presents the high level architectural workflow of the communications between the ATCC, the AT-GLP and the Metagame.

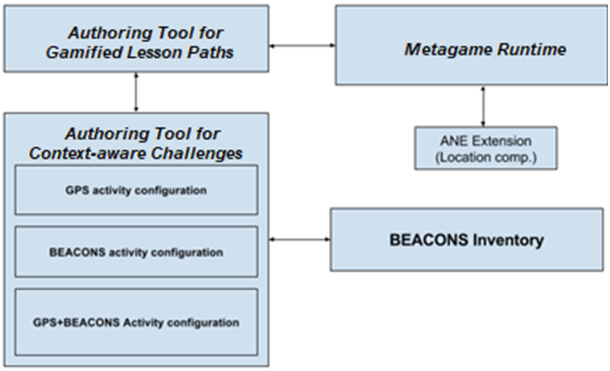


Fig. 1. The architecture of the ATCC

2.2 Creating Context-Aware Activities

After a GLP is defined in the AT-GLP, teachers can create context-aware games and activities in the ATCC. In the ATCC, teachers are also able to specify location for the learning activities in the GLP and define other parameters. The system uses a set of predefined activities to make activities, and no programming skills are required. This component together with the Beacons Inventory, allows the creation of mixed location based activities using both GPS and Beacons (or QR codes) (Figs. 2 and 3).

The context-aware activities can be part of any GLP and are created using an integrated location-based games authoring tool (Fig. 4).

It enables teachers to extend the students "game-based learning experience" beyond the boundaries of the classroom and allows them to explore the school, the surroundings of the school, and the neighborhood or the city, interacting with a real-life map.

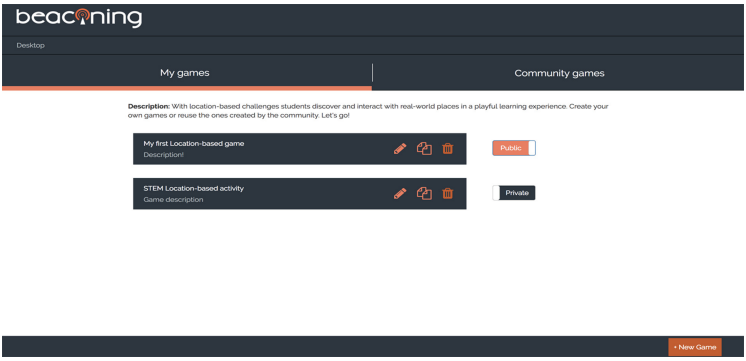


Fig. 2. The dashboard of the games used in the ATCC

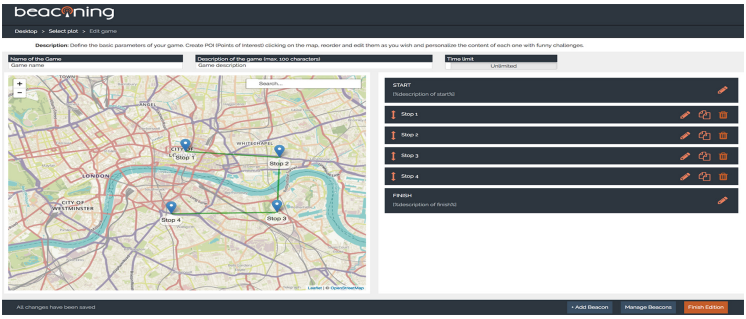


Fig. 3. Creating a "Follow the Path" context-aware activity

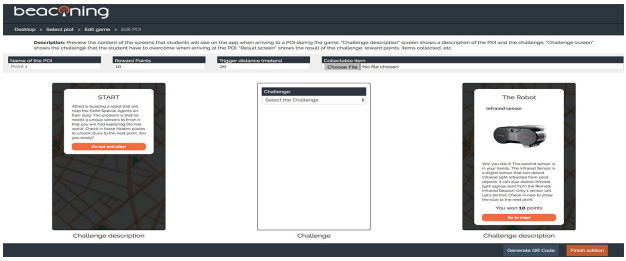


Fig. 4. Personalizing pedagogical content of the context-aware activity

Context-aware activities are a collection of POIs (Points Of Interests) where each point is associated with a learning activity like a minigame with a contextualized quiz, or a simple check-in option to verify the position of the user in the geolocalized mission.

2.3 Creation Pipeline

During the development of the ATCC, the aim was to keep the teachers experience as simple and intuitive as possible. Below there is a simplified diagram of the configuration pipeline of a context aware lesson path (Fig. 5):

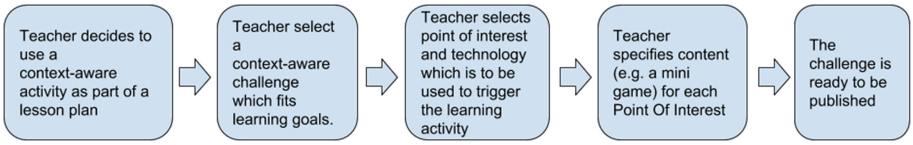


Fig. 5. Simplified creation pipeline graph

1. The teacher creating a lesson path decides if a context-aware activity fits with the pedagogical purposes of the educational activity;
2. The teacher selects a context aware activity option from the AT-GLP;
3. The AT-GLP opens the ATCC;
4. If there are any previously created or saved context aware activities, the teacher will be able to select an existing one and personalize it or create a new one;
5. When the teacher creates a new context aware activity, they can decide which technology it is going to use: GPS, BEACONS and QR Codes;
6. If the teacher selects the technology, the authoring tool will show the different context aware activity types;
7. The teacher decides which context aware activity fits the pedagogical purpose of the lesson path;
8. After selecting the context aware activity type the teacher can personalize for each step of the activity a minigame to be launched contextually to the current position of the student.
9. The tool enables to save work in progress that can be edited further before publishing an activity;
10. After finishing the configuration process, the activity can be published.

2.4 Examples of Context-Aware Activities

Context-aware services process information on the human factor (e.g. emotional state, habits, behaviors), and on the physical environment the user activates in, taking into account social interactions, co-location of others, group dynamics [10]. This context is explored by games to create compelling user experiences. Below there is a list of context-aware activities that can be used to gamify learning paths:

- *Follow the Path*: linear location-based game activity where students have to find and check-in at specific Points of Interest (POI). All points are shown in the map and the winner is the one who arrives first to the last POI.

- *Treasure hunt*: linear exploratory location-based game activity where the goal is to find a hidden treasure in the real world. Individually or in groups, students will have to find clues that give them information that has to be interpreted to find the final location of the treasure.
- *Capture the flag*: non-linear competitive location-based game where students are split into two different teams. Each team has a base where the flag is allocated. The goal of the game is to capture the enemy's flag and bring it to the base as many times as the game organizer decides.
- *Rat Race*: linear competitive location-based game where two or more teams of students have to participate on a race and be the first to reach the finish line. From the starting point to the goal the students have to solve activities in different POI's. The path of each team is different from the other.
- *Conquest*: non-linear competitive location-based game where students teamed up in different teams have to conquer different zones of the city while solving activities. Zone size and shape is automatically created by the context aware authoring tool. Zones can be reconquered by other teams. The first team to conquer a certain number of zones defined by the teacher wins the activity.
- *Jigsaw*: Linear competitive location-based game where the goal is to be the first team to arrive to a specific location overcoming activities in different POI. Different teams start the race at different POI and every time a team solves the activity of a POI a clue to the next one is shown (Fig. 6).

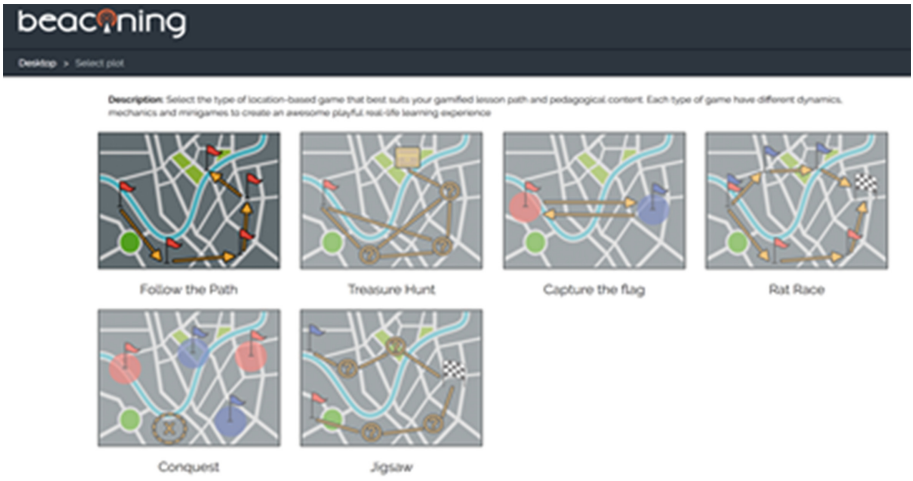
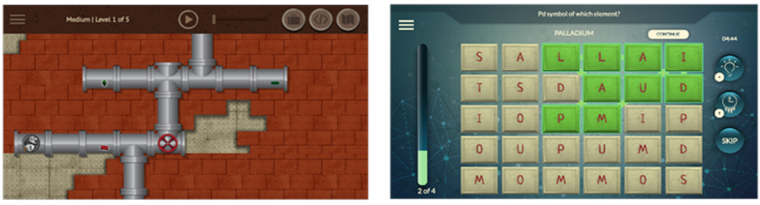


Fig. 6. Context-aware game types available on the Authoring Tool

3 Minigames

In a context-aware scenario, the learning path can integrate several minigames that are exposed to the learners as activities. When a learner reaches a certain location, a minigame is made available as a new activity. In game design, minigames are a special type of game activity, different from the main overall game experience that can address specific goals, according to choices made in the game's design. They can, for example, address specific topics or tasks engaging the player in a particular activity or can serve as a fun and entertaining experience inside the overall game story. In this second case we usually define them as "break games". From the user interface point of view, they typically provide a user interface with completely different graphic design from the main game play, highlighting that it is a different area within the game environment with a specific user interface depending on the specific aim and goal.

Mini games are short 2D web based game experiences that aim to engage the student with a different game play along with a fun activity. Minigames are inserted into a user experience workflow where a caller component (location based activity or overall meta-game) triggers the opening of a mini game, and at the end of the session, the player is sent back to the caller game. In the Fig. 7 below there are some screenshots of minigames with reusable and configurable game mechanics that have been developed to assess or train STEM skills.



RoboCode minigame Swipe&Seek minigame

Fig. 7. STEM minigames

These are two of the games developed for BEACONING. The first screenshot is taken from the RoboCode minigame, a programming and robotics specific game mechanic where the player is asked to create an algorithm to get the robot from one end of the path to the other. The creation of the algorithm involves dragging and dropping the instructions from an instructions repository to an execution area, arranging them in the correct order. The second screen is taken from the Swipe&Seek minigame, where the player is asked to answer the question by finding and highlighting the answer in the grid by dragging a finger over the correct tiles with a "Ruzzle like" game approach.

To summarize, for all games the key features of the mini game components are:

- Reusability: to use the same game while addressing different STEM topics.
- Configurability: to allow teachers and learning designers to fully customize the mini game behaviors.

- Portability: due to web based architecture, the minigames can be part of a hybrid mobile architecture, running inside a native web view component, as well as part of a fully web based architecture, both on mobile and desktop browsers, due to the liquid and responsive layout of the user interfaces.

The next section reports on the first experience teachers and students have had with using the ATCC as a part of the lesson path as well as a context aware game.

4 First Piloting

This section demonstrates the first results of using different types of games in a workshop setting. The first workshop only reports on the usage of the context-aware game, whereas the second reports on the using different elements of the BEACONING system. More workshops will be carried out in autumn 2017.

4.1 First Experience of a Context-Aware Game

The context-aware games play an essential role in the lesson paths designed for creating higher engagement and pervasiveness among the users, so this part was tested first during the BEACONING platform Demo Session at the eLSE conference in Bucharest (April 2017). This scenario is related to the LEGO Mindstorm and the Coding & Robotic Lesson Path and used the Robot Treasure Hunt game (Sect. 2.2).

The location-based outdoor game using GPS technology was created applying "Treasure Hunting" game mechanics: a linear exploratory location-based game activity where the goal is to find a hidden treasure in the real world individually. Participants had to find clues on specific Points of Interest (POI) that gave them information that has to be interpreted to find the final location of the treasure. 12 students participated in the experiment. The gameplay was constructed as follows:

- Activity presentation: the game provided explanation of the game goal.
- Clue: the system sent users a clue with information about the next POI in real world. Users had to understand and move around to find the real location.
- Map: when users were trying to find the POI, the distance remaining was shown in real time to assist them with finding it.
- Activity screen: when users arrived to the right POI, the system automatically triggered a screen with the activity to overcome: minigames, check in, upload pictures, etc.
- Final screen: when users have found all the clues until the last POI, the system showed a final screen with the reward and information related to the storytelling.

Twenty-three students, aged 16 to 18, coming from different schools across Romania were divided into teams. After installing the app on their mobile phones (different types of devices), they went outside to discover the clues. The goal was to be the first group to return after solving all activities. The feedback was collected both using a questionnaire, as well as a part of an oral discussion. The questionnaire consisted of 20 questions that aimed to identify the main types of mobile devices used by

students, playing habits (e.g. how often they play, what kinds of games they prefer), the "ideal game", and how students perceive pervasive learning. Students were enthusiastic about the context-aware, play-learning approach. They appreciated that context-aware games make learning fun, more engaging, and also easier. By integrating theory with practice, students have fun and learn without realizing it. Students considered that games help them develop their ability to retain more information. They suggested several subjects where the demoed game could be used (like for math (geometry), biology and history), and proposed improvements: the games should be more complex and more difficult to increase engagement; they should be more flexible to meet the different levels of knowledge.

4.2 Pilot Testing of Beaconing Components

Based upon the feedback from the students, the context-aware activity was improved to better fit the purpose in the lesson paths and used again. It was a part of a workshop with a pilot school aiming at engaging teachers to use the system and to show the opportunities created by designing more engaging and personalized lesson paths. On August 30 and 31, around 35 teachers from different ORT schools in France tried both minigames and a context aware activities designed according to the process described in Sect. 2.4. The location-based activity prepared for experimenting the new way of teaching used geolocalisation quests. 5 out of 35 teachers played the game in the same way as in Sect. 4.1, and then reported back to the other teachers.

The second part of the workshop was used to identify possible new Gamified Learning Paths, integrating the geolocalisation quests by imagining new ways to experience from their students. The feedback was collected in a debriefing section. Most of the teachers thought that Geolocation/Beacons provide new possibilities of improving the existing courses and extend the control of the teachers on the flow of the courses - inside/outside of the schools, thus they would be interested in elaborating new Learning Experiences further. However, they also made clear that they missed several functionalities and that we need to improve the usability, since it is not trivial to change neither the games nor the lessons paths.

5 Discussion and Future Work

This article describes the usage of an authoring system that enables teachers to integrate minigames and context-aware games as a part of lesson paths for teaching STEM subjects among students within the range of 16–24 years. It reports on the first experiences of around 50 teachers and students, where teachers have used the authoring system for adapting games to fit the individual lesson path and subject, and students have played a context-aware game. Even though the teachers reported that they would like to use it and the system is accepted as very innovative, it still requires quite much understanding of game design concept. In addition, they asked for a better usability with more functions. Based upon their feedback, we have added some functionalities that will be implemented and tested in November.

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