Blending Context-Aware Challenges Into Learning Environments

Ioana Andreea Ștefan[1], Antoniu Ștefan[1], Ancuța Florentina Gheorghe[1], Pau Yanez[2], Michael Loizou[3], Sylvester Arnab[3] and Jayne Beaufoy[3]
[1]Advanced Technology Systems, Târgoviște, Romania
[2]Geomotion, Marie Curie, Barcelona. Spain
[3]Disruptive Media Learning Lab, Coventry University, UK
ioana.stefan@ats.com.ro
antoniu.stefan@ats.com.ro
anca.gheorghe@ats.com.ro
michael.loizou@coventry.ac.uk
pau.yanez@geomotiongames.com
sarnab@cad.coventry.ac.uk
adx984@coventry.ac.uk

Abstract: There is a growing expectation for educational environments to be more flexible and more engaging, not only for students, but also for teachers. Project-based Learning and cooperative learning have emerged as opportunities to create motivating learning contexts that focus on teaching students how to find information, how to test the information they have discovered, and then how to apply that information in a creative way for a specific purpose. Moreover, it is important to consider that students, once integrated into the work force, are not individual performers. Key skills have evolved to a blend of competencies that range from STEM skills to social ones. It is equally important that students explore the skills that are not part of the standard curriculum and they learn how to collaborate, how to be self-aware, how to empathize, how to work out conflicts and so on. However, creating such rich learning contexts requires extra efforts from teachers, and existing educational tools still need to become more user friendly to encourage actual adoption. Even if opportunities for innovation exist, these have not been fully exploited and large-scale implementations remain an issue. This paper explores the added-value that context-aware services can bring to education and presents the construction process of context-based gamified learning paths that support multi-skill acquisition. The implementation is supported by an Authoring Tool for Context-aware Challenges (AT-CC) and minigames developed within the BEACONING Project. AT-CC is a tool that enables teachers, acting as learning designers, to create metagames, which are pervasive, game-driven experiences that increase student motivation and engagement. The metagames created with the AT-CC tool integrate minigames into the context-based experiences, so, when students are playing, they have the opportunity to enhance their knowledge and skills. Teachers can easily customize both the context-aware paths and the minigames to create new experiences adapted to new locations and specific learning objectives.

Keywords: metagame, minigame, GPS, beacons, STEM, BEACONING

1. Introduction

Pervasive mobile learning involves the combination of both pervasive computing and mobile learning technologies for dynamically supporting the user during the learning process (Arnone *et al.*, 2011). Furthermore, the incorporation of context-aware learning activities has been shown to be capable of enhancing both the motivation of the students in addition to improving learning effectiveness (Shih *et al*., 2011), (Kapp, 2013) and accessibility of learning activities in the future (Shuib *et al.,* 2015). Even if context-aware systems using technologies such as Global Positioning Systems (GPS) have been successfully used for teaching a variety of subjects (Jong, 2015), (Liu *et al.*, 2018), (Rawat & Kankanhalli, 2015), deploying these pervasive situations is still a challenge for teachers (Muñoz-Cristóbal *et al.*, 2014). Therefore, bringing together digital content, physical environments, mobile technology, and pervasive components to enable the delivery of anytime, anywhere, and anyway learning requires concerted actions (Cárdenas-Robledo *et al.*, 2018) that can facilitate the creation of such blended experiences.

The BEACONING Project ('Breaking Educational Barriers with Contextualised, Pervasive and Gameful Learning') has addressed this challenge by providing a set of tools that facilitates 'anytime anywhere' learning. The project incorporates pervasive, context-aware and gamified techniques and technologies and frames these under the Problem-Based Learning approach (PBL). The BEACONING platform is using multifaceted education technologies through large-scale piloting of a digital learning platform that blends both physical and digital spaces.

The PBL approach applied in the project originated from the health sciences and was introduced over 30 years ago in North America (Boud & Feletti, 1997). Between 1980 and 1980 the PBL approach was also adopted in Europe. The main characteristics of PBL is that it is learner-centred and it allows the learner to use theory, practice, skills and knowledge for solving a defined problem. A tutor can guide the learning process and evaluate its success that the end of the learning experience (Savery, 2015).

This paper introduces an Authoring Tool for Context-aware Challenges (AT-CC) developed within the BEACONING project that allows teachers acting as learning designers to create pervasive and gamified learning experiences. The AT-CC eliminates the need for intervention and assistance from software developers, by reuniting all the necessary functionalities in an easy to use interface. The tool has been tested in several schools and organizations across Europe (Baalsrud Hauge J. *et al.* 2017). The paper includes a test case of the AT-CC for children with learning disabilities that has been carried out in Coventry.

2. Creating location-based metagames for learning

The Beaconing experience reunites a set of tools that enables the creation of pervasive, gamified learning experiences. The AT-CC is a tool that has been developed by GEOMOTION within the BEACONING project with the purpose of making learning design more innovative. The AT-CC enables teachers to create context-aware Gamified Lesson Path (GLP), which are presented to the students as metagames. These metagames are pervasive, game-driven experiences that blend context-aware challenges and minigames as motivational drivers for learning. The minigames concept has been introduced by the Beaconing Project to define short games that teachers can integrate into the GLPs. Several minigames have been developed by the Beaconing partners to support the proposed approach. These minigames can be customized by the teachers to better comply to specific learning objectives. By playing the context-aware metagames, students can enhance their knowledge and skills in a fun and engaging way.

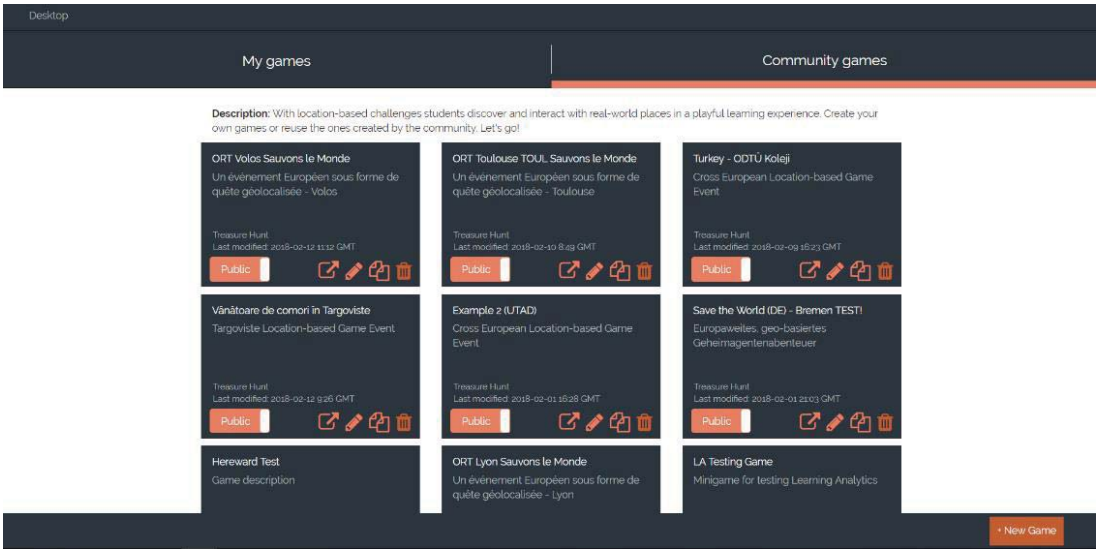
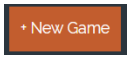


Figure 1: Location-based metagames interface

The AT-CC has an intuitive interface, where learning designers have the possibility to create a new metagame or to duplicate and customize an existing one. This feature enables teachers to create new metagames based on an existing one by using the same location, but with different challenges. Bellow we will present the steps that a learning designer needs to follow in order to create a new location-based metagame. The steps are easy to follow and do not require much time or programming skills. After accessing the application, a list with all the existing location-based metagames will open. The learning designers can choose from the following options:

- Create new metagames accessing the button 

- Test new/existing metagames accessing the button 
- Duplicate an existing metagame using the button 

- Edit their own metagames using the button 
- Delete their own metagames by clicking on the button 

In addition, there is an option to make a game public or private.

2.1 The design flow for location-based metagames

2.1.1 Create a new metagame

To create a new location-based metagame, the learning designer needs to click on the **New Game** button. A list with all the existing plots will open, and the learning designer needs to select the type of location-based game that best suits his/her GLP and pedagogical content (for example, the plot: Treasure Hunt). For each plot, the application offers a short description in order to help the learning designer select the best plot that matches their specific needs.

Figure 2: Plot selection interface

2.1.2 Metagame edit interface

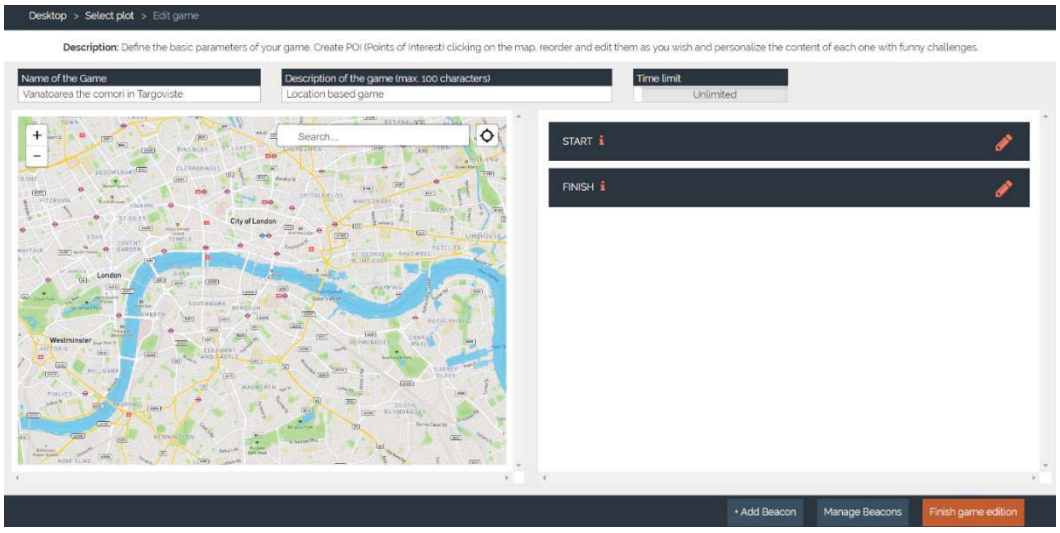


Figure 3: Metagame edit interface

After the learning designer selects a plot, the application will open the *Edit Game interface*. Here, the learning designer needs to define the basic parameters of the metagame by creating Points of Interest (POIs) by clicking on the map, reordering and editing them and personalising the content of each challenge.

The *Edit Game interface* is divided into the following screens:

- *Input of basic parameters* – the learning designer has to define the title of the metagame, provide a short description of the metagame, and set a time limit. By default, there is no time limit, but if the learning designer wants the student to complete the metagame in a certain period of time, he/she needs to click on the unlimited button and add the time limit in minutes.

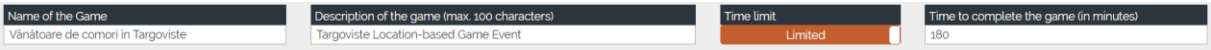


Figure 4: Basic parameters of the game edit interface

- *Define the POIs* – after selecting the location of the metagame (eg. Targoviste, Coventry), the learning designer needs to click on the map to define the POIs. Each click made on the map is considered as a POI and it appears automatically on the right side of the screen, from where teachers can customize each challenge, edit or delete a certain POI.

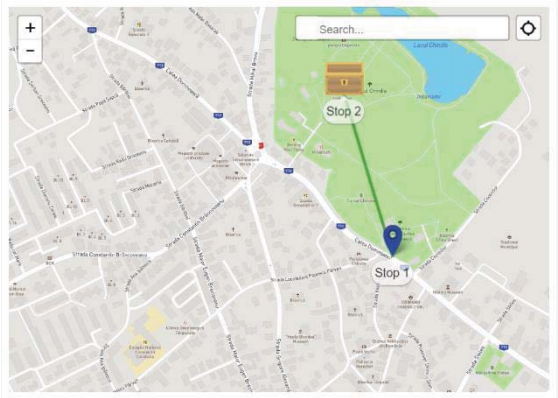


Figure 5: POIs map

- *Customising a challenge/POI* – after adding all the POIs needed, the system will display, on the right of the screen, a list of all POIs and the Start and Finish screens. In this screen, the learning designer has the following options:

- *Localise* – by clicking on the icon  a teacher can localise on the map a certain POI

- *Edit Start, POIs, Finish screens* – by clicking on the icon  the system will open the Edit POI interface.

- *Duplicate* – by clicking on the icon  the learning designer can use the same content of the POI duplicated but assigned to another POI or use the same POI but with different content.

- *Delete* – using the icon  teacher can delete a certain POI or a POI added by mistake.

- *Reorder POIs* – the systems offers a drag and drop option that the teacher can use to reorder the generated POIs.

Figure 6: List of POIs

2.1.3 Edit Start interface

The *Start screen* is the first screen that the students will see and does not depend on the location of the student. It is important to include in this screen relevant information such as terms of use, the purpose of the game or other relevant information that can help the student complete the game.

After clicking on the *Edit* button, the system will open the screen before the first challenge. In order to open the interface for editing POIs, the learning designer needs to click on the *Edit* button and fill-in the following fields:

- The title of the challenge;
- Upload an image/video that can be seen in the Start screen (if none is added then the system will display a default image), the description of the first challenge and the clue of the first POI.
- Content of the challenge;
- Clue for the next POI (the clue for the first POI).

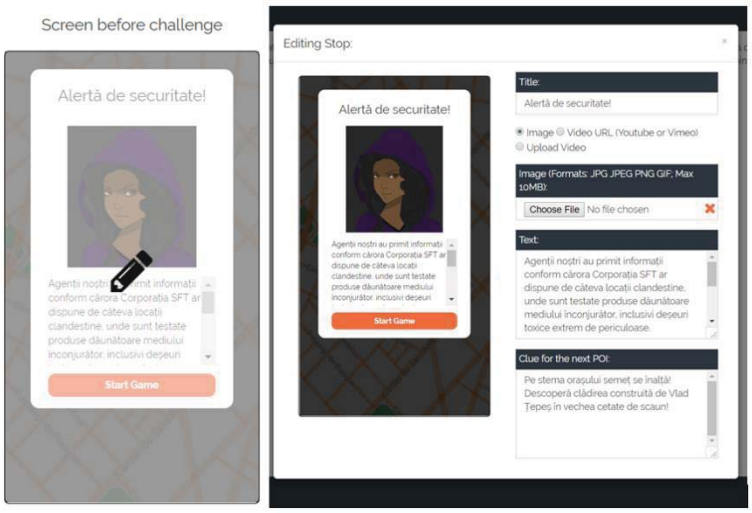


Figure 7: Start interface

All information is saved automatically by the system, so the learning designer just needs to add the information and click either on the close button or anywhere outside the popup window. This feature provides a safety net for the learning designer, in case they forget to save the game creation session. After adding all relevant content, the learning designer needs to click on the *Finish editing* button to go back to the Edit Game interface.

2.1.4 Edit POIs interface

The next step in creating the metagame is to define the POIs. For each POI generated above, the learning designer needs to add the relevant content for the specific POI by accessing the edit button of the selected POI (e.g. Targoviste POI). The system will inform the learning designer that the challenge (minigame) for the POI needs to be created and assigned from the Authoring Tool for Gamified Lesson Paths (AT-GLP) (another system developed within BEACONING project).

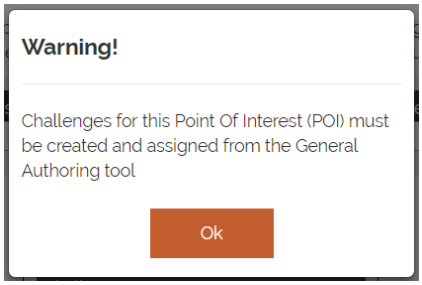


Figure 8: General information message

After approving the message above, the application will open a popup window, where the learning designer needs to add the content specific for that challenge. The *Edit POI interface* provides a set of four features and three screens for each challenge. The *four features* are defined by the following options:

- POI name - the title displayed on the POIs list.
- Reward points – points received by the student for completing the challenge.
- Trigger distance - the trigger distance must be set in order to avoid GPS location inaccuracies (some mobile phones or some geographical areas may not allow very exact GPS co-ordinates).
- Option to add a collectable item – the item that the student will receive after completing the challenge. This item will be displayed in each student's inventory.

Figure 9: Edit POIs interface basic parameters

- *The screen before the challenge.* The learning designer needs to fill in the following fields:
- Title of the challenge.
- Image of the challenge – if none is selected the system will display the default one.
- Text of the challenge that need to be completed by the student.

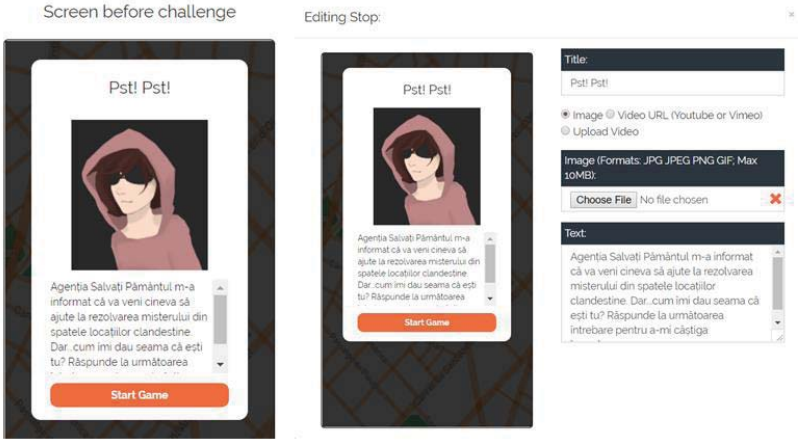


Figure 10: POI screen before challenge

- *The screen of the challenge.* The learning designer needs to add the link of the minigame created within the Gamified Lesson Plan (GLP) - this feature will be updated and the teacher will have the possibility to select from a list which mini game to use.

Figure 11: POI screen for challenge

- *The screen after the challenge.* The learning designer needs to fill in the following fields:
- Title of the POI discovered.
- Text about the POI. For example, in the first POI we used the Chindiei Tower building and we provided some historical information about the building.
- Clue for the next POI.

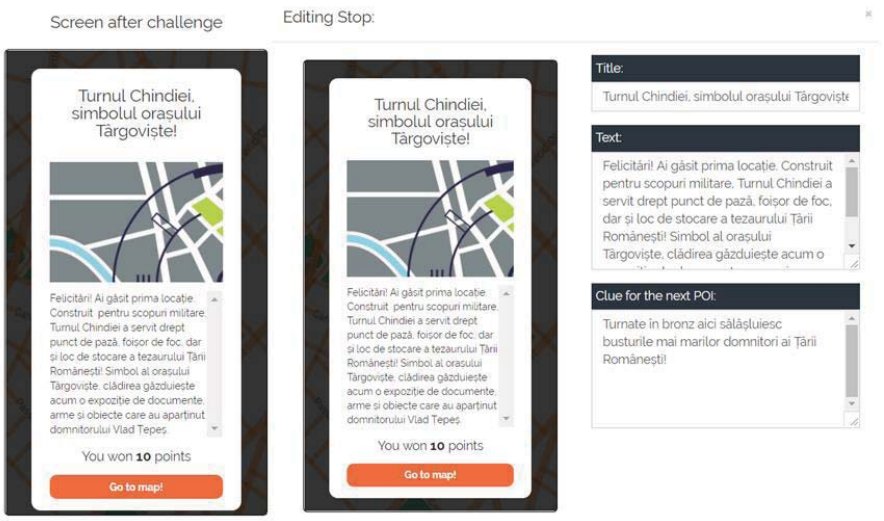


Figure 12: POI screen after challenge

To finalize the flow presented above, the learning designer needs to click on the finish POI editing button and the system will redirect him/her to the *Edit game interface*. The steps presented above must be repeated for each POI, to customize the content.

Another two interesting features of the system is the usage of media content, such as video or audio, in order to evaluate the student. For this, the learning designer should upload, for example, a video in the screen before each challenge and then provide a minigame with questions based on the information from the video. This is an interesting and interactive way for testing the knowledge of the students. In addition, the system has the possibility to add other challenges than minigames such as uploading media content. For example, in the last challenge we added the option to upload an image in order to prove that the player found the location of the last POI. For this, the student had to discover the last POI and to upload a selfie into the system.

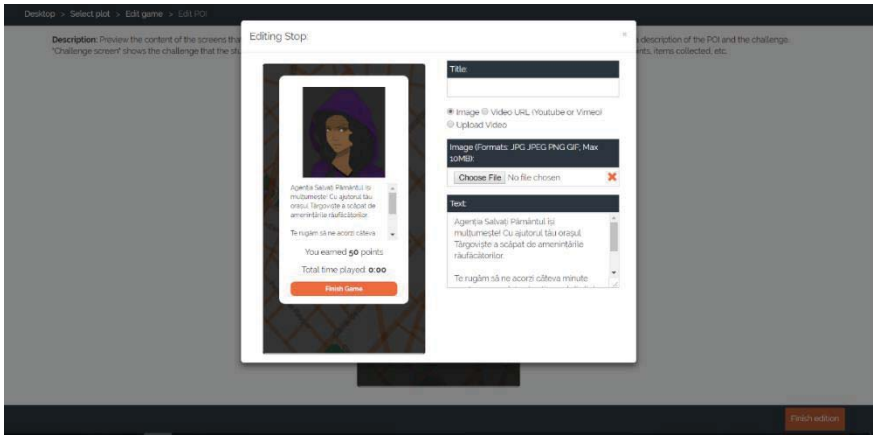


Figure 13: The last screen of the metagame

2.1.5 Edit Finish interface

The last screen of the system is the *Finish screen* where the learning designer could add a congratultion text for the students who finished the game, or other relevant information. In addition, in this screen, the system will display the total no. of points earned and the time used to complete the game

2.1.6 Save and publish the game

When the learning designer has completed all the screens, he/she must click on the finish game editing button from the Edit game interface, in order to finalize the game and make it public. Once saved, the game will be visible in the list of all existing location-based games.

3. Piloting the system for the development of a treasure hunt metagame for people with learning disabilities

The AT-CC has been used by an academy for children with learning disabilities at Coventry for the creation of a Treasure Hunt metagame in a nature-based setting. The treasure hunt, Shield Quest, was designed based on human focused design principles.

Clues and the different tasks were triggered using a combination of the participants' actions and GPS co-ordinates. The location chosen was a nature setting, a beautiful park used for scout training, so that the pilot would be even more enjoyable for the students. The environment was used for the encouragement of mobility and travel skills, both of which are very important for people with learning disabilities. Also, we took into consideration that technology and skills for using it has been shown to increase the quality of life of children and young people with learning disabilities. Below are few of the screenshots of the game sequence, which was well received by the participants.

Figure 14: The first challenge

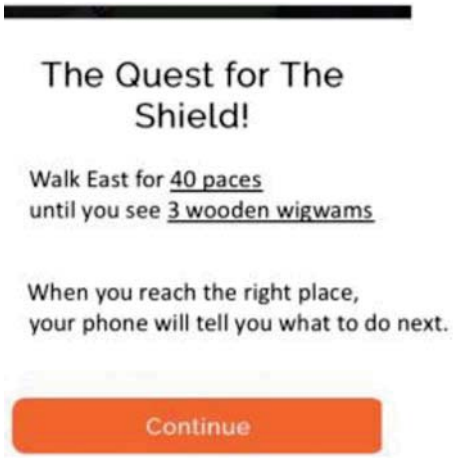


Figure 15: The clue

Figure 16: Finding the first piece

Figure 17: Uploaded image

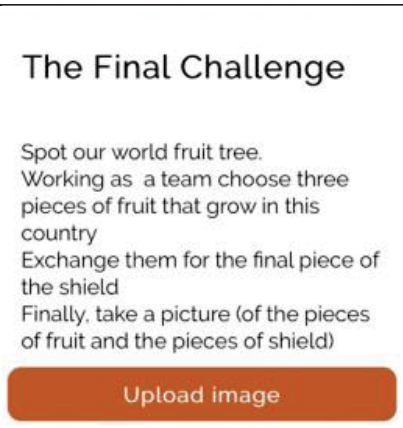


Figure 18: The final challenge

Figure 19: Completing the game

To assess the experience of creating a context-aware metagame, a questionnaire has been distributed by Coventry University among the staff of the academy for children with learning disabilities in Coventry. Three teachers have participated in the testing experiment. The questionnaire had eight questions and a comment section. All the teachers considered that the tasks at each beacon point were age appropriate and the tasks skills throughout the game were appropriate. Most importantly, they have considered that there were demonstrable effects on the four weeks the students spent working with the Coventry University. All the participants indicated they enjoyed the quest game, they thought the tasks were appropriate and were not too easy or too hard. Even if all participants said they have enjoyed playing this game-driven experiment outside, most were not interested in playing the same metagame again themselves. However, one of the teacher commented that the students might be interested to play the metagame again. Another teacher considered the activity (the “Shield game”)

held the attention of the students for the full duration and prompted significant discuss in the "after party". While Coventry University has only worked with the teachers, the school's teachers have worked with the students and they had permission from both the school and the parents to play the metagame and collect feedback. The questionnaire they have distributed to students consisted of five questions and a comment section. Five students have participated in the experiment. From the replies, 40% of students did not enjoy playing the Shield quest game. However, all students would play it again and enjoyed playing outside. 80% thought the tasks were too easy and 100% said that the tasks were not too hard. In conclusion, the Shield Quest was effective, and students had a positive experience and most would participate again.

4. Conclusion

In the last decade, it has become more and more important to enable self-directed and spontaneous learning, as well as learning that is context aware. Students are encouraged to be active in their own learning, to be self-thinking and become active consumers of knowledge. In this context, the paper explores the provision of context-aware pervasive learning that offers seamless services, adaptive services, and context-aware services facilitated by the tools developed within the BEACONING Project. The authors present a PBL approach, where knowledge is developed through working on tasks and skills authentic to the environment in which those particular skills would be used. To enable this uptake, the paper describes an authoring tool developed within the Beaconing Project to enable learning designers to create pervasive learning experiences that integrate context-aware challenges and minigames created in the project. The authors present a metagame created for children with learning disabilities, and discuss the feedback received from the participants. Future work will focus on enhancing the user experience, both for the teachers and the students, based on the feedback collected from piloting activities. The aim is to facilitate the creation of richer, context-augmented gamified learning experiences at teacher level and provide students with more engaging learning contexts.

Acknowledgements

The work presented herein is partially funded under the Horizon 2020 Framework Program of the European Union, BEACONING – Grant Agreement 68676.

References

Arnone, M. P., Small, R. V., Chauncey, S. A., & McKenna, H. P. (2011). Curiosity, interest and engagement in technology-pervasive learning environments: a new research agenda. *Educational Technology Research and Development*, *59*(2), 181-198.

Baalsrud Hauge J. et al. (2017) Exploring Context-Aware Activities to Enhance the Learning Experience. In: Dias J., Santos P., Veltkamp R. (eds) Games and Learning Alliance. GALA 2017. Lecture Notes in Computer Science, vol 10653. Springer. Cham.

Boud, D., & Feletti, G. (1997). The challenge of problem-based learning (2nd ed.). London: Kogan Page.

Cárdenas-Robledo, L. A., Peña-Ayala, A., (2018). Ubiquitous learning: A systematic review, Telematics and Informatics, ISSN 0736-5853, https://doi.org/10.1016/j.tele.2018.01.009.

Jong, M. S. (2015). Context-Aware Geography Field Trip with EagleEye: Teachers' First Experience. In *Smart Learning Environments* (pp. 77-93). Springer, Berlin, Heidelberg.

Kapp, K.M, (2013). The Gamification of Learning and Instruction Fieldbook: Ideas into Practice, Pfeiffer.

Liu, G. Z., Chen, J. Y., & Hwang, G. J. (2018). Mobile-based collaborative learning in the fitness center: A case study on the development of English listening comprehension with a context-aware application. *British Journal of Educational Technology*, *49*(2), 305-320.

Muñoz-Cristóbal, J. A., Prieto, L. P., Asensio-Pérez, J. I., Martínez-Monés, A., Jorrín-Abellán, I. M., Dimitriadis, Y. (2014). Deploying learning designs across physical and web spaces: Making pervasive learning affordable for teachers, Pervasive and Mobile Computing, Volume 14, Pages 31-46, ISSN 1574-1192, https://doi.org/10.1016/j.pmcj.2013.09.005.

Rawat, Y. S., & Kankanhalli, M. S. (2015). Context-aware photography learning for smart mobile devices. *ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM)*, *12*(1s), 19.

Savery, J. R. (2015). Overview of problem-based learning: Definitions and distinctions. *Essential readings in problem-based learning: Exploring and extending the legacy of Howard S. Barrows*, *9*, 5-15.

Shih, J. L., Chu, H. C., & Hwang, G. J. (2011). An investigation of attitudes of students and teachers about participating in a context-aware ubiquitous learning activity. *British Journal of Educational Technology*, *42*(3), 373-394.

Shuib, L., Shamshirband, S., Ismail, M, H. (2015). A review of mobile pervasive learning: Applications and issues, Computers in Human Behavior, Volume 46, Pages 239-244, ISSN 0747-5632, https://doi.org/10.1016/j.chb.2015.01.002.

Yang, S. J. H., Zhang, J., Chen, I. Y. L. (2007). Ubiquitous provision of context-aware web services. *International Journal of Web Service Research, 4*(4), 83–103.