Improving Learning Outcome by Re-using and Modifying Gamified Lessons Paths

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Abstract. A main challenge for teachers is to provide good educational offers that appear both appealing as well as motivating to students to learn about the content according to the curriculum. Educational games are thought to be a good complementary way of provide this learning environment, but, so far, the adaption of educational games to a specific context is not only costly but also requiring a lot of knowledge related to game design. This article provides some examples on how gamified lessons paths can be changed in a simple way and how different components can be re-used, in order to save costs and time and to improve the overall quality of the learning experience.

Keywords: Minigame · Metagame · Reuse · Adaption of lessons paths

1 Introduction

For teachers it is important to create a positive, rich and motivating learning environment, to try to spark interest amongst the classroom, but also to ensure a streamlined and successful learning process. Using games for learning is a great way to make learning motivating and engaging [1].

In the last decade, more and more tools have been developed to support teachers in their efforts to create more engaging and immersive learning experiences. Digital Educational Games (DEG) and gamified educational applications have emerged as a mean to balance the ludic approach, and the didactical goals. [2] has highlighted the difficulty to leverage DEG outcomes, stating that their success depends on the context, the content, the topic, and the pedagogical competences of the teachers. These factors coupled with the diversity of game genres, the multitude of age groups targeted by serious games [3], the advanced skills required to perform adaptation of games to new learning contexts and also the difficulty to transfer the DEG learning outcomes to the real world [4] make DEG design challenging. Research has also explored the use of learning versions of existing games [5], highlighting a new dimension of complexity to the learning design.

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Research efforts made to support a better DEG design have been diverse, stressing upon the importance of the learning design phase. The iLearnTest Framework [6], for example, has focused on providing game templates that could facilitate game construction. The Activity Theory-based Model of Serious Games (ATMSG) discussed by [7] provided a representation of how the game elements are interconnected, and how these elements contribute to the achievement of the desired pedagogical goals. [8] have presented the evaluation of the design of Collaborative-Competitive SG (CCSG), and identified a set of guidelines for future educational CCSG.

In this context, the key aim of the BEACONING project was to provide an ecosystem that reunite tools that enable teachers to easily construct, adapt and reuse playful pervasive learning experiences. The Gamified Lesson Path (GLP) is the core concept around which the experience is build. Such GLPs can be created and customized using two main authoring tools: the Authoring Tool for Gamified Lesson Paths and the Authoring Tool for Context-Aware Challenges. These authoring tools enable different levels of the customization of metagames, which are narratives that drive the game play on the student side, and of minigames that are used as the main assessment tools of the learning outcome. With the support of these tools, teachers can personalize the learning units to the specific student's needs [9]. In order to ensure the reuse of the different learning paths, a set of templates, as well as a taxonomy have been developed [10], however, past experiments have shown that the application is not that intuitive as intended, and thus there is a need for practical examples on how either re-purpose or re-design GLPs.

This paper therefore presents an easy-to-use authoring tool can support reuse and adaption of GLPs. The main objective is to show how such a tool can reduce the teachers' workload while enabling the personalisation and adaption of learning material to specific subjects. The approach is based upon principles presented in [11–13] and is based on the experience collected in the small- and large- scale piloting [14].

The overall BEACONING piloting focused on STEM with a large age distribution. The four pilots related to logistics had a narrower age – 18–24. This is obvious related to the fact that logistics is not a part of a standard curriculum for the younger age groups. The section below describe the different pilots and the experiments with around 400 participant.

The next section will first outline the requirements for reusability, then describe the adapting process. Sections 3, 4 and 5 describe the two case studies, while chapter four derives some guidelines. Section 6 concludes and give an outlook to next steps.

2 Requirement for Re-use

Previous works have defined a set of components that are suitable for reuse [15], as well as resources that nurture personalization of gamified learning experiences to specific settings. The main purpose of adapting existing applications is not only to reduce costs, improve quality and reduce the time to market for games, but also provide support for teachers that embark on the adaptation of game-based learning experiences. However, most serious games are one of a kind development and even small changes require a mix of specific knowledge making it difficult for teachers to carry out this process without additional support.

A framework that support the reuse have been developed in [16–18]. It defines specific components and how these needs to be described for easy reuse. A main challenge is to connect the instructional design and with the overall game design. According to [18] the usage of narrative serious games mechanics can support this process and a tool that specifically support this is ATMSG [7] in the analysis of the original gamified lessons path in order to ensure that the learning mechanics and the game mechanics are well aligned (Fig. 1).

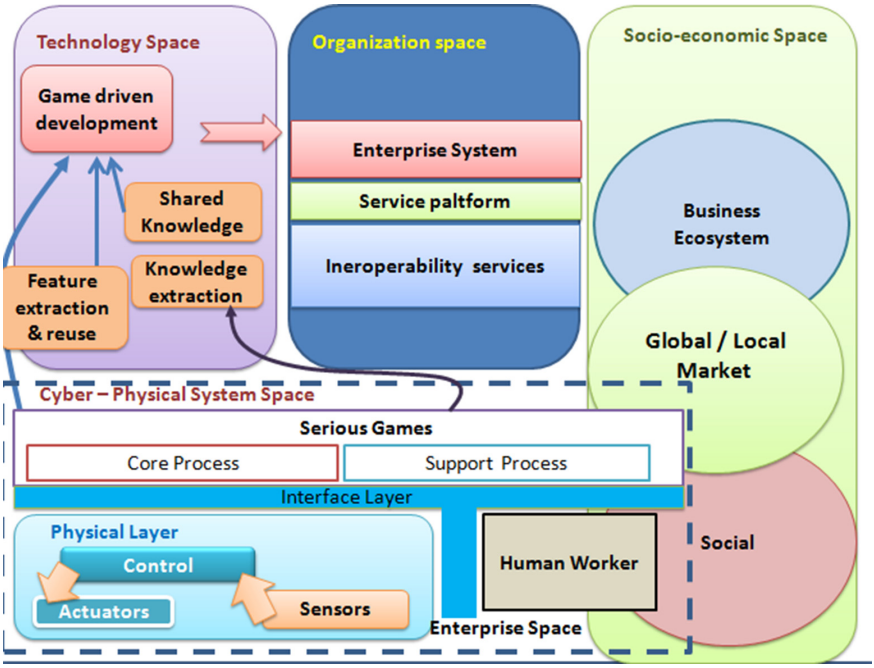

Fig. 1. Game embedded in ecosystem [17]

However, the application of such analysis methods are not so trivial, so in this article we show how an authoring tool can be used instead [17]. By cloning we can keep the passive components (i.e. narrative structure) and graphical assets, and the teacher can focus on repurposing the active components (i.e. components that evolves and changes such as the learning content that is adapted for a specific subject or the tests carried out via the minigames). The reason for choosing this approach is that teachers are very familiar with developing lessons plans, in which they align the class content with the intended learning outcomes and decide upon the tools to use for mediating this content to the individual students. The BEACONING project intended to provide 'anytime anywhere' learning by exploiting pervasive, context-aware and gamified techniques and technologies, framed under the Problem-Based Learning approach [10]. The backbone of the solution is a platform that offers teachers the possibility to create just one gamified lesson and reuse it in different ways by using an authoring tool. The main goal of this is to lower the barrier for Science, Technology, Engineering, and Mathematics

(STEM) teachers to introduce and use personalised and pervasive learning as a part of their classes. One of the innovative aspects of the Beaconing platform is the possibility to reuse a GLP [18]. A main aspect so far was the overall usability and the relation to the learning experience for those used to experiential learning, as well as the usage of the authoring tool, and the supporting material in the form of different types of guidelines for the GLP construction and adaption at project level. In addition, a user guideline for this specific GLP making the ILOs clearer to the students was developed for this specific GLP.

3 Experiences in Using GLPs on Logistics

Experimental Set Up of the 3 Studies
This section is based on the analysis of a small scale pilot (with 22, 18, 16 participants) carried out at university level and 2 large scale pilot studies for VET ((200 participants, and 100 students+30 teachers) within the field of logistics [14]). 2 of the pilots were location based, while one large scale pilot was PC based. The course topics on the university courses where on technology support in logistics, while the topics for the VET were on cohesion and technical knowledge.

The university students were very familiar with game based learning as teaching method, but this does not hold for the VET. Age range were 20–24 and 15–21.

The GLPs
University Level: A location based GLP with 6 quests was used for this purpose. The lesson path is an introduction to logistics and technology usage in a warehouse and production environment. The main focus is on the technologies and how they work. It is designed to be used before the students are familiar with the logistics operations (processes). The player has to physically walk through the hall and to observe how the implemented technologies work in different operations.

Large Scale 1 VET. As a part of the large-scale piloting, ORT, a global education network that coordinated the piloting activities in the BEACONING project, developed two different GLPs on logistics topics: one location based and one designed for PC usage. The pilot was carried out in collaboration with PROMOTRANS (Beaconing, 2019b).

This pilot used a geolocation based GLP (ESCAPE game). This was created by the teachers (11) and played by 200 students age 18–20, BTS, 1. & 2. Year. The GLP aimed at building cohesion between the teams, as well as to check the technical knowledge (through the mini-games) and was used during the first school day. It also offered the students the possibility to explore the surroundings. The teachers who constructed the GLP got support from the ORT team, which was very experienced in developing GLPs and using the BEACONING authoring tools.

The second large-scale pilot was also organised by the same organisations. The setting was based on this experience and therefore a PC based GLP was developed. This time 30 teachers, and 100 students were involved. The age group was 15–21 years, coming from Bac Pro, 1st and 2nd year and 10th Grade. The game play took around 30 min [14].

Results

University Pilot. The experiment showed that the pedagogical approach- PBL, experimental was considered as motivating and realistic. The pedagogical approach was well known to students and teachers and they were therefore comfortable with the way the GLP was implemented. The large majority of the students achieved the intended learning outcomes. However, the GLP contained six different quests, some of these mini-games were perceived as knowledge tests and not well related to the topic. Regarding the devices that players used for the location based game, they all stated that it is not playable on a smart ´phone, but they had good experience with using tablets. Furthermore, none of the participants had special needs, so this part could not be tested.

VET Pilot 1. The feedback from the participants showed that the tool is very suitable for fostering team cohesion, as well as several management topics. It was highly appreciated that the teachers could integrate their own questions. Even though it was perceived as a good learning experience, there is room for improvements- this is specifically related to the knowledge retention of the geolocation based. This could be solved by using a flipped-class room approach with a PC GLP. Secondly, regarding the usage- the teachers suggest to re-use it every quarter- both for team cohesion as well as for giving the students an opportunity to test their progress. Regarding the technical equipment, this pilot used smart phones and concluded that 3 smartphones are needed per group.

VET Pilot 2. The perception of the ability of the game to foster discussion and interaction between the younger and the older students as well as for discovering new fields was good. Furthermore, it was also perceived as positive that the game play could be prepared 1 day in advance. Weaknesses were also discovered - it is noted that it is very important that the students can reach the mini-games even if they did not manage within the time frame. This was only possible using the teacher interface, furthermore- from a technical point of view, approaches like bring your own device is a challenge and also the risk of connectivity issues. The different pilots indicates that there is still a challenge in the usage of the authoring tool, which was perceived as too complex and time consuming, the usage of quests in the location based GLP and the subjective perception of learning with new methodologies. A new set of guidelines for adapting GLPs was developed and used for the re-design of the logistics described below.

Reuse of an Existing GLP on Logistics in a Different Context

Based on the experiences in the previous pilots and the challenges in reported by the university teachers in doing the adaptions, we redesigned that one using the cloning function of the VET 1 and then adapting this to fit the needs of the students and the target group- reusing the some of the minigames from the university pilot.

The new game play consists of two GLPs with 5 and 4 quests that the players need to complete. The quests are designed using 5 minigames namely Generic Quiz, Checkers Game, Drag IT, Match IT and Planet Ninja. As reinforcement and repetition is crucial while learning, Generic Quiz and Planet Ninja is repeated in the GLPs. It makes it easier for the player to focus more into the lesson content rather to explore the mechanics of it. This GLP is based upon elements from the existing GLPs. It has been re-purposed

to target different aspects of logistics compared with what covered so far. The narrative concerns logistics for off shore wind-power plant segment placements. Important for this type of logistics processes is the often-low access to infrastructure, the weather related restrictions both in constructions phase as well as in operating and maintaining phase. The narrative is constructed in such a way that it can easily be adapted to on-shore and off-shore wind power parks, but the one tested so far is related to off-shore logistics (Fig. 2).

Fig. 2. Starting screen for repurposed logistics GLP

The GLPs covers the topics of safety and security regulations in harbour area, risks both within the harbour area and off shore as well as regulations on heavy goods on vessels. For the monitoring the development of the GLP as well as the technical testing of the GLP, the same testing protocols as described in [14]. The testing was carried out by a test engineer. The first experiments with the new GLPs were carried out in the last week of June 2019 with around 15 students from the University of Bremen. The preliminary results of the tests shows that the students improved their skills on harbour logistics. The results of PoI 1 – which were related to generation of energy shows that the students could not relate this to the overall learning objective of the course and that the relevant questions were perceived as a knowledge test (similar to the previous test). The results of PoI2 and 4 which comprises topics on loading, unload, safety and risks show that the students achieved the intended learning outcome for the safety regulation and fairly well for risks. PoI 3 was related to tools for management of the complex logistics handling. First results shows that most students failed this ILO. In the future, we therefore intend to integrate a video showing the operations and the interactions. Furthermore, we also intend to investigate the integration of a haptic game in the GLP for this issue, but for that more tests with a larger user group will be carried out.

Regarding the challenges in developing and adapting new GLPs, the feedback from the responsible teacher indicates that it was much easier than in previous versions, also because she could look at different GLPs and clone parts and that the guidelines have reduced the time needed to implement, but that a support from technical team and more

experienced GLP developers. In order to compare, we also set-up a second case study for a different topic and a different age group.

4 Re-purposing a GLP on Chemistry

The starting point was a simple GLP designed to be used in Romanian Secondary schools. The target group of this particularly GLPs was high school students. The intended learning outcome was set according to the curriculum in chemistry related to the Periodic Table and element construction and characteristics. The whole GLP was constructed as a narrative, explorative geo-located treasure hunting game, using the Authoring Tool for Context-aware Challenges (AT-CC) [20]. The students had to play the role of a detective and the game mission was to discover who stole an important re-search paper. They had to find the intruder and the documents stolen by visiting different locations in the city of Targoviste in Romania (Figs. 3 and 4).

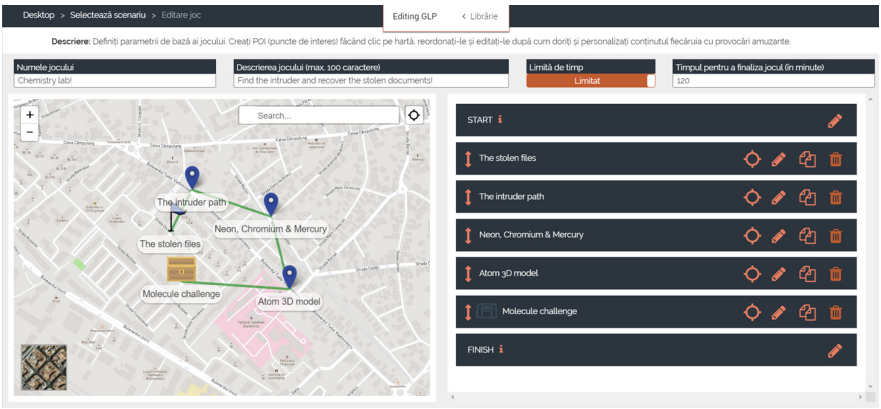

Fig. 3. Location based game template

During the game play, the students were further evaluated through three minigames, integrated into the narrative flow that is directly related to the intended learning outcome:

- The *It's elemental game* was created using the minigame "Drag IT", where students must discover the missing elements from the periodic table. The expected duration was 120 min, and upon arrival on specific pre-defined points of interests, additional information was provided.
- The *Atomix* game was created using the minigame "Generic Quiz", where students must give correct answers to five questions about the characteristics and atomic structure of five periodic elements. No time limit had been customized for this minigame and some of the questions provided hints for the answer.
- The *Molecularium* game was created using the minigame "Match IT", where students must match the name of a chemical product with its graphical representation. As a hint, students could use the chemical formula provided, in order to identify the molecule.

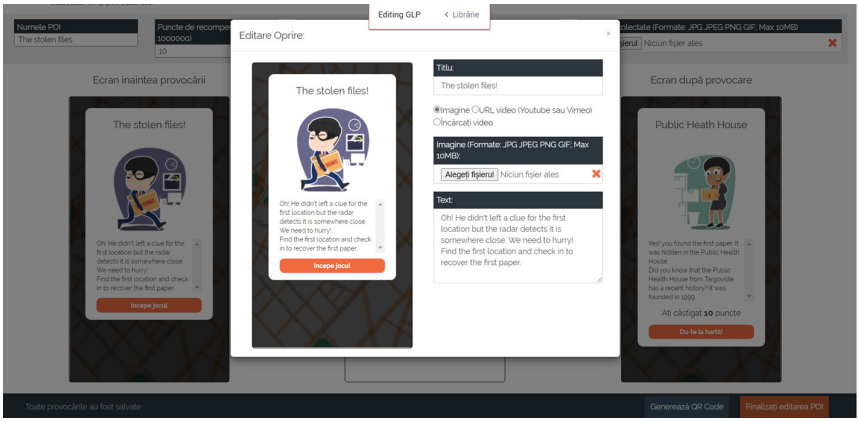

Fig. 4. Location based game - narrative flow

Re-purposing

The initial GLP on chemistry and environmental sustainability was constructed as a geo-located experience that let the student explore the environment of the city they live in and it comprised a set of minigames on chemistry. Both of these components can be reused as such or can be customized. The example below reuses the geo-located part of the GLP and replaces the minigames with other minigames. This is the simplest form of re-purposing a GLP, since it does not require the teacher to re-align the instructional design, nor the higher order learning-mechanics with the game mechanics [15]. It is sufficient to replace the different minigames.

One of the two examples discussed here aims to teach students about the history of Targoviste targeting the same age group. The students can explore various époque specific architectural styles and such constructions characteristics can be used to identify in which period the building has been built (Figs. 5 and 6).

Fig. 5. First clue

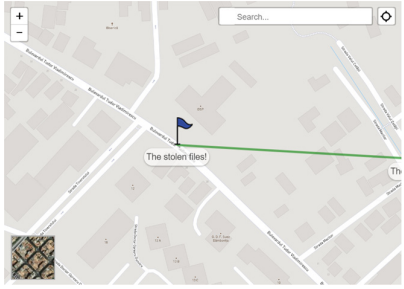

Fig. 6. Location: Public Health House

The structure of the GLP can be repurposed as follows:
Starting point: The Students' Club
Title: Looking for the thief!

Text: After searching through the room, you discovered that the intruder left a note with five locations where he will hide the documents. In order to find out where he is hiding and to recover the papers, you need to go to all the locations, following the clues. Hurry up! Time is limited.

Clue for the first POI: This institution protects public health and well-being

POI 1

Screen before the challenge

Title: The stolen files!

Text: Strange! In this note, three chemical elements are specified: 10 Neon, 24 Chromium and 80 Mercury. What does it mean? Find the first location and solve this riddle in to recover the first paper.

Screen after the challenge

Title: Public Health House

Text: Yes! you found the first paper. It was hidden in the Public Health House. Did you know that the Public Health House from Targoviste has a recent history? It was founded in 1999.

Clue for the next POI: Bears the name of the one who built the Royal church from Targoviste (Fig. 7).

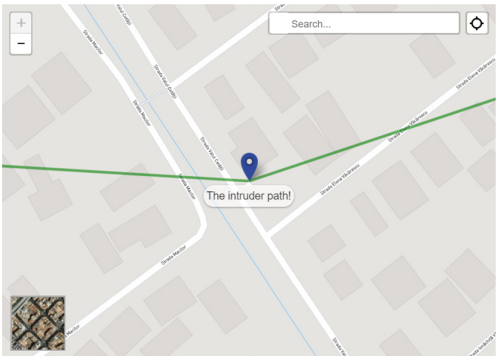

Fig. 7. Location: "Petru Cercel" high school

Screen before the challenge

Title: The intruder path!

Text: Did you read the clue? We need to hurry! If the paper gets on dubious hands, it is bad!

Screen after the challenge

Title: Petru Cercel, ruler of Valachia

Text: Yey! You recovered the second document. It was hidden in the School "Petru Cercel". Despite the fact that Petru Cercel ruled only 3 years, he built one of the most important churches in the city but also he created the first zoo in the country.

Clue for the next POI: There is a pharmacy, but also a private clinic.

POI 3

Screen before the challenge

Title: Neon, Chomium, Mercury

Text: Another note with some strange text. In this one it is specified 118 Gold and "Light and colourless". Who knows what that means, but I think this information will be useful.

Screen of the challenge

Minigame: Generic quiz

Screen after challenge

Title: Hyperici pharmacy

Text: Congratulation! You discovered the third location. Hyperici derives from the word "Hypericum", which means "Above the heath" and it is also a genus of flowering plants. From this type of genus, it can be created two anthraquinone derivative: Hypericin, which acts as an antibiotic and Hyperforin which is a reuptake inhibitor.

*Clue for the next PO*I: University building in whose name is included the symbol of Potassium.

POI 4

Screen before the challenge

Title: Atom 3D model

Text: Hurry up and find the next location!

Screen of challenge

Check In

Screen after the challenge

Title: International Conference Center of University Valahia

Text: Yes, you found it! Did you know that here will take place between 14-16 September 2018, the National Conference of Chemistry - Pre-university Education, 10th edition.

Clue for the next POI: In 1930, a plate was placed here with the text "In memoriam Dr. Dimitrie Oprescu, primary care physician".

POI 5

Screen before the challenge

Title: Molecule challenge

Text: What is this all about? Another note with ambiguous content! Three red, one blue, one white - Nitric acid and "A lot of molecules - Lemon salt"

Screen of the challenge

Minigame: Matchit

Screen after the challenge

Title: Dambovita County Hospital

Text: Hurray! You found the last document which was hidden in the County Hospital. Did you know that the first county hospital was built in 1822 and contained 4 rooms, a house for the doctor and another one for the pharmacy?

Finish

Title: Did you catch the thief?!

Text: Well, we found all the documents but where is the thief? Oh! He left a note where he specified that he will go back to the lab to take the rest of the research paper. We need to hurry back to the lab!

The second example presents the repurposing of the GLP for a different age group, in our case bachelor students entry year as an idea of how playful repeat basic knowledge. As explained above, there is a set of minigames that support the course specific learning objectives. The story as such is quite general. Since we have decided to keep the geo-located part of the GLP, it is important that we ensure that the minigames we replace are replaced so that the player feel immersed in the game play- the simplest form of doing this is to keep the context-awareness. This can simply be done by adjusting the difficulties in the tasks. As an example: instead of searching for the missing elements, the students could look for isotopes and other more detailed information and then use a minigame of type Match It to configure molecules. In this case, it is however important to keep the narrative in mind. In principle, one would assume that the second adaption is easier than the first, since we keep most of the initial structure.

This is currently designed for high school students, and thus it needs to be re-assessed that such a story is relevant and engaging for the new age group. This will require some more alignment works, but the steps will in both cases be similar. The generic approach is described in the next sub section for all three cases

5 Stepwise Approach for Reusing and Adapting

The Authoring Tools developed within the Beaconing project combined with the open-source approach enable various interventions that facilitate reuse and adaptation. Even if the H2020 project has ended, the Beaconing Platform remains functional and the authoring tools are available for users that authenticate.

The GLPs presented in this paper can be subject to different levels of adaptation:

a. *Cloning a GLP*. Such a GLP has exactly the same structure, the same narratives but not the same learning content as the original.
b. *Removing or replacing a minigame with a new one*. To increase the flexibility of the adaptation process, the structure of a GLP can be altered and the minigames used in the initial GLP can be removed or replaced. In our example, we reuse a GLP designed for high school for undergrad students. In this case, it is not so suitable to use the Drag it minigame (which was used for the missing elements of the periodic system), so it was replaced with a different type of game - the Swipe and seek minigame.

Even if the opportunity for reuse significantly reduces the time and resources required to create gamified learning experiences, perpetual reuse can impact the player experience in a negative way, leading to demotivation and lack of engagement, as the user is exposed to the same narratives and images. Therefore, changing the learning content does not suffice. Since most of the Beaconing code has been made available as open source, further levels of adaptation are possible by applying changes directly in the code.

c. *Changing the narratives*. Narratives represent a key mechanic of engagement. The structure of a GLP can be reused (POIs, minigames), and the narratives can be changed to create a new experience for the players. This reduces the time required to create a new GLP from scratch and provides more flexibility in adapting a GLP for a specific subject of topic.

d. *Changing the images in a GLP*. Seeing the same images over and over again can have a negative impact on player motivation. Changing the narratives might not suffice. Therefore, exposing players to a new set of images can increase their motivation to play the GLP.

6 Discussion and Conclusions

Employing gamified lessons paths provide engaging alternatives to traditional learning environments. However, to empower teachers to fully harvest the benefits that GLPs can bring, it is necessary to address the barriers that prevent successful GLPs redesign and adaptation. These steps can be used for re-purposing every existing GLP and is a straight forward approach. But, even though the teachers adapting the GLPs reported that the new guidelines and the authoring tool supported the process quite well, they also highlighted the following:

- The current version of the AT-GLP does not provide an overview of the minigames; therefore, teachers find it difficult to follow the content that is associated to a minigame, e.g. if a quiz has several questions, it is difficult to navigate between them.
- It remains difficult for teachers to identify quickly how a particular game is relevant to a certain component of the curriculum, as well as assess the accuracy and appropriateness of the content within the game with the subject that is being taught, which shows that we are still dealing with the same challenges in alignments [15, 16, 18, 21].
- Even if a GLP provides an engaging setting, using the same narrative structure and the same images over and over again makes students loose interest. Personalizing a GLP requires access to digital resources such as images and especially sets of images that can be used across a narrative path to redesign a GLP. In addition, as pointed out in example 2, where we changed the target group- the narrative has a very important function in the current GLPs, and therefore this needs to be very well aligned to the target group [18, 19].
- Moreover, the current versions of the authoring tool enable limited access to such changes. For example, to change the images within a GLP, the teacher has to make changes in the GLP code. Therefore, the skills required for substantial changes across a GLP are still high. Even if the source code is available, advanced ITC skills are required to perform more in-depth changes and adapt a GLP to meet specific requirements of a certain subject or of specific learning objectives.

The paper presents the reuse settings of a GLP, using tools developed in the Beaconing project and presents approaches to reuse and customization. Future work includes testing of the customization capabilities, in order to further improve the experience both on the teacher side, as learning designers, and on the student side, as players.

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