Tangible or Digital? A Comparison Between Two Tools for Designing Asymmetric Role-Playing Games for Learning

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Abstract: The design of serious games is a complex process, particularly when it comes to scripting. We are particularly interested in asymmetrical multiplayer serious games, i.e. where several identified roles have different tasks and objectives. These games are usually collaborative to be closer to real-life work or learning situations. Few methods and tools have been designed to assist in the making of scenarios for this type of game. Our aim here is to compare two tools for this purpose: one tangible and one digital, both based on the same conceptual model, and to compare the advantages and the limitations of these two tools. We also want to make suggestions to help choose between them depending on the context. We base these comparisons on qualitative experiments carried out with the two tools. The results tend to show that the use of a tangible tool is preferable in the ideation phase, at the very beginning of scenario design, because it appears to be quicker to familiarise yourself with. The digital tool, on the other hand, would be more effective in the long term, to manage several scenarios and update its content.

1 INTRODUCTION

These days, students have few opportunities to confront real-life professional situations that they could only approach through internships and group projects. However, studies show that there is a skill transfer from virtual world to reality (Rose et al., 2000; Torkington et al., 2001). As Freitas (Freitas and Neumann, 2009) points out, role-playing is effective before taking a job to avoid mistakes in the real world. Indeed, serious games have been developed in this field. Fabricatore (Fabricatore, 2000) proposes the following definition of a serious game:

> [...] a virtual environment and a gaming experience in which the contents that we want to teach can be naturally embedded with some contextual relevance in terms of the game-playing [...].

They provide a way of tackling realistic situations with the advantage of being able to replay the situation several times for learning purposes (Marfisi-Schottman et al., 2013). Thus, serious game seems suitable for students to confront professional situations because this type of activity would be complicated to repeat in real-life conditions. We therefore want to focus on serious games that are multiplayer, to incorporate the cooperative aspects of the professional world. The definition of cooperation and its distinction from collaboration is not unanimous as shown by Castañer (Castañer and Oliveira, 2020). Here, we will use the term "cooperation" as described by Roschelle (Roschelle and Teasley, 1995), to know:

> Cooperative work is accomplished by the division of labour among participants, as an activity where each person is responsible for a portion of the problem solving. We focus on collaboration as the mutual engagement of participants in a coordinated effort to solve the problem together.

In the field of games, it is common to use the term cooperation to talk about games that we consider, according to this last definition, to be collaborative. In addition to being cooperative, the games we are addressing are "asymmetric". We therefore chose to use this term to describe the type of game that interests us. This means that the different players will not have

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the same role to play (Meyer et al., 2021; Li et al., 2017; Bortolaso et al., 2019). Each role will have its own pedagogical objectives, tasks and skills. We call this type of game Role Learning Games (RLG). The aim is for players to understand how these roles work together, to learn to manage their time and to take account of the actions of other players and their influence on their own work. However, Marfisi (Marfisi-Schottman, 2023) points out the problem that existing authoring tools for designing serious games are either not available to teachers or require development skills.

Our general problem is: how can we help teachers and educational engineers build a RLG scenario? This type of game is still underdeveloped and this can be explained by the lack of tools and methods to help design them (Guigon et al., 2021). Nevertheless, a model (RLG Model) (Guigon, 2022) has been built for this purpose (Figure 1 is an overview of the model). It has been reified in the form of two tools: a tangible one (RLG Kit) and a digital one (RLG Maker). This model defines that a RLG (in orange on the figure) contains at least one mission (black). And each mission includes at least two quests (blue): one for each role. To achieve the educational objectives of each quest and obtain rewards, the role will have to complete tasks (red) of various kinds. However, it is essential to have at least one task in common with another role by quest. This common task allows and highlights the cooperative side of the game (green). These are the main characteristics of this model.

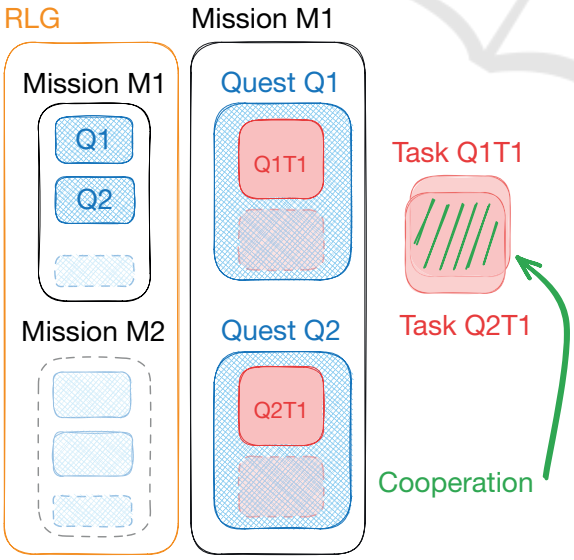

Figure 1: RLG Model overview.

The model was reified into two tools, one tangible and one digital, to evaluate it and to tackle different constraints in different contexts. What are the benefits and the limits of these two types of tools?

We can suppose on one hand that a tangible tool offers more flexibility, facilitates collaborative design and is better suited for brainstorming (Pernin et al., 2012) or will be the quicker to familiarise yourself with (Sutipitakwong and Jamsri, 2020) or to perform the activity (Cuendet et al., 2012; Schneider et al., 2011). Moreover, (Roy and Warren, 2019) grants advantages of tangible cards that could apply to our Kit, that is to say:

- Facilitating creative combinations of information and ideas
- Providing a common basis for understanding and communication in a team
- Providing tangible external representations of design elements or information
- Providing convenient summaries of useful information and/or methods
- Are semi-structured tools between blank Post-it notes and detailed instruction manuals

On the other hand, the digital tool could allow designers to share their scenario with other designers (Emin et al., 2010; Marfisi-Schottman et al., 2010) or to create them without worrying about creating inconsistencies (Marne and Labat, 2014). Another advantage is to analyse user data (Oliver-Quelennec et al., 2022). We assume that they will complement each other and provide advantages inherent in their format.

This lead us to our research question: how can we help designers choose the appropriate tool for scripting RLG? The designers we are targeting are teachers and educational engineers because they can help teachers implement this type of resource in the classroom. To answer this question, we will first present the two tools and then describe the experiments that have been set up to evaluate them. We will then be able to draw up a comparison of these tools to help designers in their choice.

2 TOOLS PRESENTATION

The RLG Model was reified in the form of two tools in order to evaluate it. These tools have been tested with teachers several times allowing continuous improvement.

2.1 RLG Kit

This Kit comes in the form of a set of wooden puzzle-type pieces (see Figure 2), rewritable and magnetic.

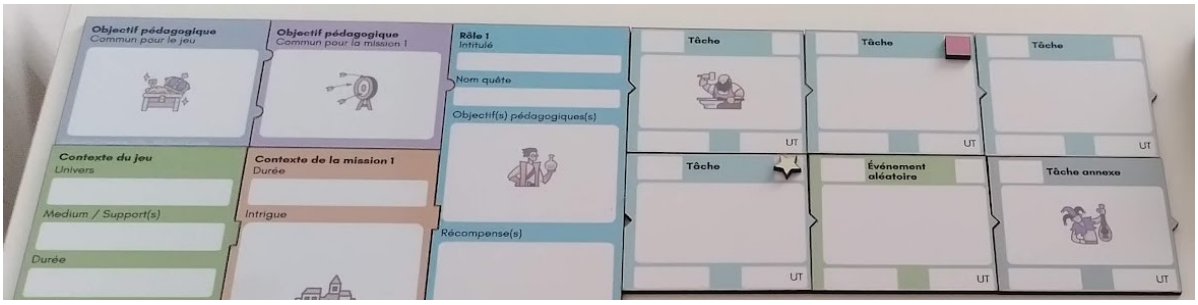

Figure 2: Some tiles of the RLG Kit: educational objectives, background, role & quest, and some tasks.

The puzzle shape was carefully chosen, implicitly influencing the designers to use them in a certain order by following the nesting of the pieces. To define this order, five experiments were previously conducted with the target audience. The experiments presented below (see subsection 3.1) led to the addition of an expansion to the basic Kit, allowing the addition of more fun features such as non-player characters, additional roles and resources for instance.

Some tiles were also added after replicating the scenario of commercial asymmetric multiplayer board games (such as ROOT, The Werewolves of Miller's Hollow, CS Files and Scotland Yard) with the RLG Kit. These tiles are, for example, steps allowing you to segment the scenario, the possibility of blocking another player in one of their tasks if the game is rather competitive, or the possibility of choosing between several tasks during your turn.

The Kit also contains a paper booklet to guide designers step by step on the tiles to fill. This booklet is in two parts. The first part guides the user on the essential steps to complete to build the skeleton of the game. The second part details the tiles of the expansion of the Kit and explains how to improve your game. In addition, an example sheet shows how to place the tiles together and use the tool to its theoretical maximum potential (comparing tasks between roles, for instance). The sources of the files are available[1] to reproduce the Kit using a fablab (a.k.a. digital manufacturing laboratory).

2.2 RLG Maker

RLG Maker is a digital adaptation of the RLG Kit. It has been designed to be as close as possible to the tangible version and thus to reduce the time of adaptation and understanding of a new tool (see Fig. 3). In addition, its format makes it possible to further guide users by arranging the tiles in the recommended order.

Furthermore, some options inherent to certain tiles are available by clicking on them. An important option has been added to this version: the scenario backup. Indeed, it is possible to stop the scenario at any time and download the backup file of your project (in json format). This allows the designer to resume their work later by importing their file and to share it. Therefore, this also allows the users to work on multiple scenarios thanks to multiple files.

To guide the designer, the booklet used for the Kit has been adapted to the digital version and can be downloaded from the tool. However, to avoid having to search in a PDF, the tile boxes have placeholders to give examples of the expected content, and tooltips appear when hovering the tiles or boxes to explain what is expected. Then, to help users follow the right order in filling the tiles, a tutorial was implemented following the experiment presented in section 3.2. It also explains how to browse the tool depending on the hardware used (mouse, pad or keyboard).

The tool is accessible online[2]. It is planned to make RLG Maker sources available with each new major update. The tool is currently available in English and French and can easily and quickly be translated into other languages.

3 EXPERIMENTS

To validate these tools and improve them as well as the underlying model, qualitative experiments were set up for each. Note that this research is placed in the epistemological paradigm of pragmatic constructivism (Avenier and Thomas, 2015). Indeed, we reproduce ecological situations with our end users (teachers and instructional designers in our case). Thus, we place them at the heart of our experiments to study the construction of asymmetrical LG. To do that, we developed, collaboratively with end users, a model and tools to build those games and collect data about their use. Model and tools allow us to study if the users have a better understanding of the creation

[1]Download the Kit design files: https://bit.ly/RLGkit

[2]RLG Maker: http://rlgmaker.imt-nord-europe.fr/

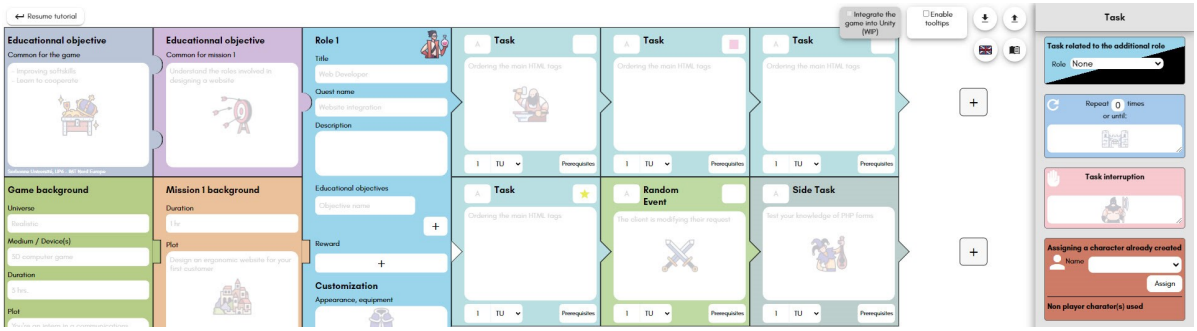

Figure 3: Some tiles of RLG Maker: educational objectives, background, role & quest and some tasks.

of RLG. Moreover, we work in the field of Technology Enhanced Learning (TEL) focused on IT.

Then, we apply the principles of Design-Based Research (DBR) (Wang and Hannafin, 2005). Each stage of the design process for these tools has gone through several iterative phases, thanks to experiments with end users. For example, the order in which the design stages are carried out, or the use of the tools (usefulness, usability and acceptability) have been the subject of several experiments followed by improvements. All of this has led to refinements to the underlying model at each iteration. The Kit experiments presented here were all part of the same iteration, and it was modified following these experiments. Furthermore, we comply with the ten principles of the DBR set out in the article by (Mandran et al., 2022). We use the THEDRE (Traceable Human Experiment Design Research) method and its associated framework to guide us in the DBR. .

Each group was audio-recorded and the sessions were filmed. The organization of the sessions was similar: they began with a briefing phase of around 15-20 minutes on the presentation of this type of game, we explained what was expected from the session, and the testers filled out a form to find out their level of mastery and knowledge on the subject. Then, the scripting period lasted an hour on average. The leader, identical for all sessions, only intervened when participants called for help. Finally, for half an hour, the volunteer groups could present their project, followed by a debriefing to find out how they felt about the tool, what they liked and what needed to be improved. Everyone also completed Brooke's SUS questionnaire (Brooke, 1996) to assess the usability of the tool.

3.1 RLG Kit Experiments

There were three experiments with the RLG Kit. This tool being a reification of the RLG Model, the main goal was to evaluate the tool, the elements that compose it and therefore, if the model allows the design of a RLG.

Table 1 presents a summary and comparative view of the experiments. The duration of the experiments was not identical because it depended on the participants' available time. The first session took place in the teacher's free time. For the second experiment, it was divided into two 45-minute sessions because it took place during their lunch break. For the last experiment, it took place during a seminar gathering teachers and educational engineers from engineering schools.

We can see in Table 1 that two of the experiments led to the outcome of two games, one for high school and one for middle school (see Figure 4).

Figure 4: Games made with the RLG Kit in class.

Table 1: Experiments conducted with the RLG Kit.

Experiments	1st	2nd	3rd
Testers	1 teacher (high school)	8 teachers (middle school)	15 teachers (engineering school, divided into 5 groups)
Duration (hours)	3	1,5	2
Material	1 RLG Kit	1 RLG Kit	5 RLG Kits
Goal	Create an asymmetrical serious game scenario for a high school course using the Kit	Create an asymmetrical serious game scenario to revise the French A-levels with the Kit	Discover the Kit and create fictional scenarios with the Kit
Subject	French	French, mathematics, history-geography, technology, physics-chemistry, life and science studies	English, composite materials, law, industrial engineering, optics, mathematics and electrical engineering, IT
Game set up with students	Yes	Yes	No

3.2 RLG Maker Experiment

RLG Maker has so far been tested once with eight educational engineers who work in higher education and will be tested a second time with teachers from engineering schools. As for the RLG Kit, we evaluate the RLG model through another reification, RLG Maker. RLG Maker is a web application developed in Javascript and the Angular Framework. In addition to this, for this experiment, a paper guide (similar to the one downloadable from the tool) was offered to the participants. As the latter was used, this means that the tool did not answer all of their questions. This explains why a tutorial incorporated into the tool was subsequently implemented.

During this experiment, there were eight educational engineers, divided into teams of two to design a scenario for an hour (see Figure 5). This experiment took place during a seminar bringing together educational engineers from a group of French engineering schools.

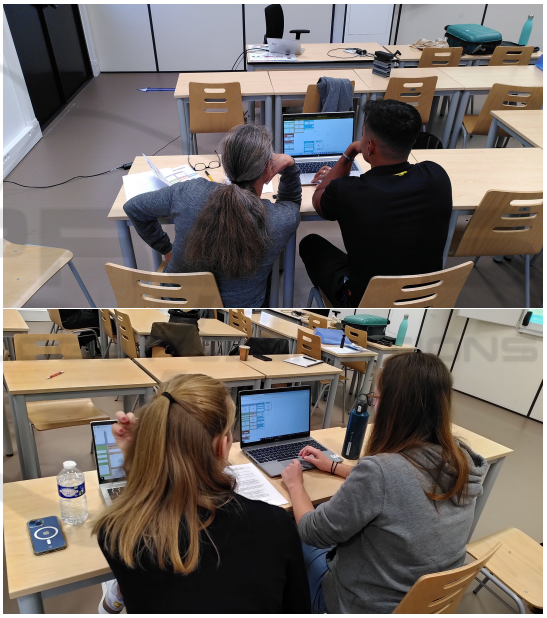

Figure 5: Experiment with RLG Maker.

4 TOOLS COMPARISON

Here are the positive and negative points of each tool that we have observed through experiments with qualitative data. These observations were cross-referenced with sentences during the debriefing or during the session. For the record, we call the puzzle pieces “tile” and the white boxes that make them up “box”.

4.1 RLG Kit

4.1.1 Pros

Thanks to the experiments, a few observations were made:

1. We could see that the main advantage of the RLG Kit is its quick handling. It was observed in every experiment. Indeed, being able to manipulate puzzle pieces is done without any difficulty.
2. The tool seems suited to part of our target audience which is teachers (seen in every experiment). Erasable markers are available to fill in the boxes

of the tiles. In addition, the pieces are magnetic so they can easily be used on a whiteboard.

3. The format of the Kit allows several people to handle the tiles at the same time (seen in every experiment).
4. This format seems to arouse interest and motivation among designers who seem eager to write on the tiles and manipulate them (seen in every experiment).
5. Finally, the fact that all designers can participate in the construction of the scenario on the tool seems to favour the scenario conceptualisation phase. That is to say that everyone can give their ideas and write them on the tiles (seen in every experiment). The scenarios produced with the Kit and RLG Maker (the online tool) for the same duration seem more accomplished with the Kit. Indeed, the paper guide advises you to take a certain number of basic steps to build your scenario and these steps are more advanced with the users of the Kit than with RLG Maker for the same duration of the experiment.

4.1.2 Limits

Here are observed limitations of this tool:

6. The fact that the Kit is erasable is a strong point for its reusability, but becomes a weakness if you want to store it between two design sessions. It was observed during the 2nd experiment. Indeed, by storing the tiles or handling them carelessly, the tiles can then be erased without the possibility of going back as easily as with a keyboard shortcut.
7. Being a tangible tool, it is really made for in-person design sessions. Lending the Kit to work separately is possible but not recommended due to the tiles being erased during storage (seen in the 2nd experiment).
8. The number of tiles is limited per Kit, so you would have to add tiles if you want to create a very large game (seen in the 3rd experiment).
9. The complete Kit with extension is made of wood, so its weight and size must be taken into consideration. Even if it fits in a briefcase, if you want to have several copies to develop several games in parallel, it can become bulky and heavy to transport (seen during the preparation of the 3rd experiment). One Kit fits into a box measuring 43x32x13,5cm, or 19 litres.

In addition, certain limits were not observed during the experiments but are known, namely:

- With one Kit it is only possible to create one game at a time, if you wish to create several simultaneously, you must therefore acquire more Kits.
- It is possible to upgrade the Kit by creating new tiles but this takes time and requires materials and access to specific machines (seen after the three experiments for the creation of the expansion).

4.2 RLG Maker

4.2.1 Pros

Here are some advantages observed during the experiment:

10. The main observed advantage of this tool is that participants could save their scenarios . It is entirely possible to stop your scenario at any time, download the save file, then re-import it to modify it next time. This functionality was used by the leader to analyse the scenarios created by the participants. It was then possible to analyse every activity performed in the tool, chronologically.
11. Some participants could use the tool without opening the paper booklet. Indeed, there are tooltips and placeholders to explain every tile and box.
12. Changes to the tool can be implemented very quickly depending on the modifications to be made, for instance: a text modification, adding a field to a tile, changing a color is quick and easy. Being able to improve the tool after this experiment has proved useful.
13. Contrary to the Kit, since the tool is digital, it does not take up space. Only a computer or a tablet with an internet connection is needed to launch it. It is then possible to work on it and download the backup without connection. It is therefore possible to use it easily. For this experiment, there were four groups but this caused no transport problem for the experiment leader.

Even if it was not observed during this experiment, we can note that since this is a digital tool, there is no limit on the number of tiles available.

4.2.2 Limits

Some weak points have been observed with this tool:

14. Handling was more difficult for the users. Indeed, manoeuvrability was not optimal during this experiment so they had to learn how to move, zoom in and out, and use some features. These were not present in the tangible format and that take time when getting started with the tool.

15. Even if the time between the end of the instructions and the moment when users started writing on the tiles is rather similar between the two tools (between 4 and 9 mins for RLG Maker and between 3 and 9 mins for the Kit), users of RLG Maker used this time to familiarise themselves with the tool while those with the Kit took this time to read the guide and find an idea for a scenario. RLG Maker's users struggled more moving forward and seemed more lost when implementing the scenario in the tool.
16. Since the tool is on a computer, only one designer can manipulate it at a time. Communication is therefore important so that other designers can get involved in the construction of the scenario. During the experiment, the two members of a group opened the tool on their laptop, only one implemented the scenario but the second wanted to help her teammate find elements in the tool so she searched how to do it on her own computer (see Figure 5).

The following remarks were not observed during the experiment but are known limitations:

- The first constraint for its use is the need to have a computer (or a tablet) with an internet connection to load the tool.
- If the computer encounters a battery problem or other technical problem, it is possible to lose all its data if the designer has not saved his scenario regularly. In fact, there is no database attached to the tool to avoid any General Data Protection Regulation (GDPR) problems.

4.3 Recommendations According to the Context

Our problem is to help teachers to choose the most suitable to their goals. Table 2 takes into account the observations we made during the experiments with the RLG Kit and RLG Maker. In this table, the presence of the "+" symbol means that this tool is appropriate to the proposed characteristic. When there is a "++" symbol it means that the tool in question is more suitable than the other regarding this aspect. The "-" symbol means that this tool is not appropriate for this characteristic.

Considering the criteria in this table, we can see that the two tools seem complementary: where one reaches its limit, the other supports this aspect and are quite balanced.

One possible use to take advantage of the benefits of both tools would be to start by using the RLG Kit during the conceptualisation phase, so that all designers can interact with the material (seen in 3.) and help with scenario design (as seen in section 4). Once the first design session has been completed, then implement the scenario obtained in RLG Maker to save it (as seen in 10.) and be able to modify it remotely or separately. All designers could then have access to it and consult it as they wish. Note that it is advisable, according to the experiments carried out, to have between two or three designers with the RLG Kit, if there are more then it is preferable to divide the quests of the different roles. Indeed, during the experiment with middle school teachers, there were eight designers and the game had four roles. As each of the roles covered a different discipline: French, Mathematics, History and Science, then the teachers of these disciplines worked separately on the quest that concerned them. However, before dividing up the work, they had to agree on the plot of the game and when the different roles would cooperate. Then, they built their quest around these common tasks.

Concerning RLG Maker, the experiment was only carried out with pairs and it seems to work well. We assume that it would be possible for a maximum of three people to use the tool on the same device. Beyond this number, users might be more comfortable using another device such as a projector.

Table 2: Comparison of the usage characteristics of the RLG Kit and RLG Maker.

	RLG Kit	RLG Maker
Face-to-face	++	+
Remote	-	++
Manipulability	++	-
Easy to use	++	+
Conceptualisation	++	+
Collaborative design	++	+
Design in several times	-	++
Multiple simultaneous scenarios	-	++
Transportability	+	++

5 CONCLUSION

To conclude, this paper presented two tools to assist in the design of asymmetric role-playing games for training, mainly intended for teachers and educational engineers. The aim of this article was to compare these two tools, the RLG Kit (tangible) and RLG Maker (digital) to understand the advantages and limitations of each of them.

We have outlined the advantages and limitations of the two RLG scenario design tools based on experiments with the target audience. Then, we have proposed a comparative table to help designers choose between the two tools based on the context and their constraints. Each of them having its strengths, it is then possible to benefit from all these advantages by combining the two tools. That is to say, to use the tangible Kit in the conceptualisation phase to involve all the designers as much as possible, then to implement the scenario on RLG Maker to be able to continue the work, if necessary, remotely and to save the scenario in a more lasting way. Indeed, as in Model Driven Engineering, one of our future objectives is to be able to load the scenario into a gaming environment like Unity or Godot.

We can confirm that the advantages of the cards cited by (Roy and Warren, 2019) in the Introduction were, for the most part, found during the Kit experiments.

(Pozzi et al., 2022) offered teachers a game to design collaborative learning activities using a board in three different formats. Each format had its advantages and disadvantages, but their hybrid augmented reality format could be the most advantageous by combining the qualities of the tangible and digital formats. This could be a new avenue for our project and worth studying in detail.

We are currently looking for a way to automatically recognise the pieces of the tangible Kit to automatically implement the tiles and their content in RLG Maker using a photo, for example. This would avoid having to copy what is already written on the Kit.

In the meantime, we are continuing experiments with RLG Maker because we are in a process of continuous improvement (in accordance with Design-Based Research). The next experiment will test a new functionality which aims to check the scenario. This will ensure that the quests can be completed at the same time for all the roles, and if the players can carry out common tasks simultaneously. To date, there has not yet been a game developed with RLG Maker since the experimentation aimed to test the tool to improve it and not to produce one or more games, but our objective is to promptly develop one with it. These improvements may have an influence on the tool itself (ergonomics, accessibility for example), but also on the Kit and the model if new elements appear with the tests.

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