

# Design patterns to support gamification-based learning activities

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**Abstract**—The application of game elements in an educational context requires a formalization of the design process. Some recurring problems are often found during this process, mostly related with student engagement and participation in learning activities, shared beyond a specific course or syllabus. On that regard, design patterns are a useful tool that helps to identify and standardize those problems, providing a transferable solution. In this paper, we present a template serving as a guideline in the creation of learning design patterns that intend to offer a gamification-based solution, as well as the collaborative design methodology used for the development and validation of several design patterns with this approach.

**Index Terms**—design patterns; learning activities; gamification; frameworks

## I. INTRODUCTION

The use of game-based activities in an educational context builds upon the study and use of the traits that make games attractive in order to generate engagement in students (concentration, effort, collaboration, etc.) when trying to achieve their learning goals. On that regard, many studies have been published showing the merits of this approach [1]. Therefore, taking game elements into consideration at the course design stage can be a good strategy to help fight some of the problems related to student motivation.

The application of game elements in an educational context is not trivial. It is essential to clearly state which are the specific problems that need to be solved, as well as using a formal method for the design process, usually with the help of a gamification framework or methodology. However, after this process, it is often the case that the proposed solution only applies to a very particular scenario. However, some of the problems that need to be solved actually tend to be recurring, applicable beyond a specific course or subject. In this kind of situation, design patterns may be a useful tool to help identify and standardize the solution [2]. In this case, to create reusable gamification-based design patterns in educational scenarios.

Design patterns originated in the field of architecture [3], but have been successfully integrated into other disciplines, such as software engineering (*software design patterns*) or more recently, pedagogy (*learning design patterns*). They are usually based on a vary simple structure: a) a situation or context, b) a statement of the problem that needs to be solved, and c) the proposed solution to the problem. There is complete freedom about how each part is further developed, often relying only in natural language (i.e. not a formal

modeling language). This freeform approach makes them easy to create in an ad hoc manner, but also open to ambiguities and interpretations when they need to be implemented.

In this paper, we take into account the current literature on gamification frameworks and learning design patterns in order to extend this basic structure, proposing a template that helps in the development of gamification-based patterns in educational contexts. The goal of this template is to provide a clear roadmap about the most important aspects that must be taken into account when proposing the pattern's problem statement and solution in the context of gamification design, by specifying all the information that must be defined in order to properly provide a gamification-based solution. Following, we describe the methodology used in the development and validation of a set of gamification-based learning activities design patterns. In order to better exemplify its application, we include a sample design pattern that was developed at Universitat Oberta de Catalunya (UOC) [4] using this template.

This paper is structured as follows. In Section II we briefly present the rational and the research background around the use of design patterns in the educational field. From there, in Section III, we propose a template structure for the gamified learning activities design patterns. Next, we explain the creation process of the design patterns from a methodological standpoint in Section IV. Then, Section V presents a sample pattern, chosen between the several we created, following the template, as well as some results on regards to the evaluation of its implementation in a course. Finally, we conclude this work and provide some insights on our current and future work in section VI.

## II. BACKGROUND

Learning design is a complex activity that requires the use of instruments and representations to manage and understand their abstraction [5]. Design patterns are an example of this type of mediating artifacts used in the design process [6]. During the last years, design patterns have started to be applied in education under several denominations such as pedagogical patterns, learning patterns, pedagogical design patterns, patterns of learning design, etc. According to Seoane Pardo & Garcia Pealvo [7], this introduction has occurred in a more natural way in border areas between technology and education where epistemological and methodological perspectives from different disciplines intersect. This is probably the reason why

there are many examples of the use of learning patterns in the fields of e-learning and educational technology [8]–[11].

Learning design patterns provide general references on learning based on educational knowledge, but at the same time leave the necessary margin for the decision making of those who design. In words of Mor & Winters [12] they have the explicit aim of externalizing knowledge to allow accumulation and generalization of solutions and to allow all members of a community or design group to participate in discussions relating to the design. Therefore, the use of design patterns is based on two important needs: to guide practitioners in designing learning environments and to create a common 'language' for all those involved in multidisciplinary learning design teams. In short, they try to capture the expert knowledge of teaching and learning practice, and to do so in a compact, easy-to-communicate and accessible way for non-experts.

Despite the numerous documented benefits of using design patterns in education there is still little evidence of their acceptance and use among teachers [5]. The most common barriers to their use associated with either the learners or practitioners are based on the relevance, accessibility and format [13].

In the context of gamification, even though there are many different frameworks which can guide the design process [14], the use of design patterns is not very common in the literature. Usually, it is about listing sample patterns, invented or identified by the authors in an ad hoc manner, and not about the design process itself. For instance, the proposal in [15], heavily inspired by software engineering and modeling languages, presents some patterns of basic game resource control. The proposed patterns are mainly concerned on organizing commonalities from a game mechanic design standpoint. A less complex approach can be found in [16], mostly about serious games, but also including two highly abstract gamification design patterns (named "Progress" and "Social"). Beyond the basic concept, they are just briefly described. The only approach where the problem is formalized from the end-user's standpoint, not the designer, can be found in [17]. The authors discuss a list of possible patterns based on the basic pattern structure (context, problem, solution) in the context of a company's workforce, such as keeping the workspace clean or performing routine tasks.

### III. A DESIGN PATTERN TEMPLATE TO DEVELOP GAMIFIED LEARNING ACTIVITIES

Up to our knowledge, no proposal in the area of gamification addresses the issue of pattern definition and development itself. On that regard, we propose to take advantage of some of our previous work on gamification design frameworks and learning design patterns [18] to further extend the basic three-part pattern scheme. The proposed extended learning design pattern template is summarized in Figure 1. It is now composed of five parts: name, context, problem, solution and evaluation metrics. In our approach, further structure and granularity is especially added to the "problem" and "solution" parts, providing some

guidelines during the definition process, helping better align learning design patterns with a gamified approach.

Name	
Context	
Problem statement	- Detailed description
	- Forces
Solution proposal	- Actions to motivate
	- General description <ul style="list-style-type: none"> <li>• Rules</li> <li>• Metaphor</li> <li>• Tool</li> </ul>
	- But...
	- SPARC self-evaluation
Evaluation metrics (optional)	

Fig. 1. Outline of the proposed pattern template.

Following, we provide the description of each part, but the sample pattern presented in Section V may better clarify each one.

#### A. Name and context

These are two brief sections that serve as introduction to the pattern description.

**Name:** Serves as the pattern's unique identifier and should quickly provide an idea about its content. It can be a catching single word followed by a more explicit short sentence.

**Context:** A short description which contains the situation where the pattern can be applied, as well as the purpose or intent of the pattern

#### B. Problem Statement

This section explains the problem to be solved as well as some of the aspects that must be taken into account in order to see the big picture. We propose first starting with a very short, high level description (1-2 sentences) as an introductory text to provide a quick idea, as a preface to the following subsections.

**Detailed description:** A thorough description of the problem using natural language. It can include bibliographic references or figures which help better explain the situation at hand.

**Forces:** A list of the relevant forces and constraints that could intervene, and how they interact/conflict with each other and with the pattern's intended goals and objectives. This should clarify the complexities of the problem and which trade-offs may be necessary to take into account.

Finally, once the problem statement has been laid out, the pattern designer must reflect on a single question: is the

exposed problem mostly motivational? A gamification-based approach will be appropriate when the answer is "yes".

### C. Solution proposal

This is probably the most important part of the pattern. Again, we propose to start with a brief summary, 1-2 sentences long, just as an introduction to the more thorough description in the following sections.

**Actions to motivate:** A short list of concrete (as much as possible) actions that this pattern intends to motivate on students. The identification of this list of actions is useful during the evaluation of the pattern's application.

**General description:** This is a detailed description of the proposed solution, using natural language. We propose to structure this section following the *SPARC* simple design framework [18]. The proposed gamified learning experience must be laid out according to three viewpoints: (1) the **rules**, which describe the basics of the activity mechanics and interactions; (2) the **metaphor**, which contextualizes use of the rules, giving sense to the actions that students must carry out; and (3) the **tool** used to implement the rules and the metaphor. They need not be taken into account in this specific order, but the one that makes more sense for the proposed solution at hand.

**But...:** This is a list of possible pitfalls or problems that could happen when the pattern is implemented, foreseen *a priori*.

**SPARC self-evaluation:** In order to reflect on the suitability of the proposed solution, we also suggest to use the *SPARC* evaluation framework, which is applied after the design process is finished and serves as a sanity test for any gamified proposal. It is based on five dimensions:

- **Sense** - Will the proposal make sense to the student? Is it coherent within the context of a learning process?
- **Purpose** - Does the solution actually try to motivate the actions enumerated at the start?
- **Autonomy** - Does the proposal allow, or even encourage, students to make meaningful choices? Does it avoid being railroaded?
- **Relatedness** Do student actions have some impact on the rest of students, or the course itself?
- **Competency** - Does the proposal ensure that the rules and tool are within the students expertise? Will students be able to master the rules and the chosen tool? It is important to remark that, in *SPARC*, competency is not related with the ability to achieve learning outcomes, since it is assumed to be correct (i.e. the course content and scheduling is considered suitable).

### D. Evaluation metrics

Once the pattern is implemented for a specific scenario at a latter time, it is important to assess its degree of success.

For this reason, it is recommended that for each action to motivate (see *Solution definition*), a sample evaluation metric is specified. These metrics also help establishing which are the pattern's ultimate goals from a quantitative standpoint.

## IV. PATTERN CONSTRUCTION METHODOLOGY

The proposed pattern template was the basis of a project, carried out during the two semesters of the year 2016, where several design patterns were developed and tested. As any learning design process, the methodology for the development of design patterns requires discussion, reflection, criticism and implementation. Therefore we used a collaborative methodology, where students and teachers from different disciplines met and discussed through a series of participatory phases. Our aim was that the patterns developed not only reflected the informed perspective of the participating teachers, but also the experience of the learning process of the students themselves.

Once the design patterns were elaborated, the second semester was devoted to the pilot implementation of the patterns in the design and development of the learning activities of several courses. These pilot implementations were also object of assessment which allowed to fulfill two different goals: a) the refinement and validation of the design patterns themselves and the analysis of their use in supporting the design process b) the analysis of the application of gamified learning activities in the context of our institution.

The specific phases of work were as follows:

### *Phase 1: Conceptualization and definition*

The starting point was the conceptualization and definition of requirements and needs: analysis and selection of gamification models and frameworks, conceptualization of design/evaluation instruments and co-design methodology, identification of participants and courses, evaluation metrics, etc. One of the main outputs of this phase was the elaboration of the template for the gamification-based learning activities design patterns.

### *Phase 2: Design pattern development*

We used participatory dynamics to identify recurrent problems in practice and to elaborate possible solutions. More specifically we run several discussion groups with students in order to identify common problems that they encountered in their everyday experience of study. Next, we conducted new series of discussion groups with teachers in order to confirm the problems identified as recurrent ones in their teaching practice and to explore the solutions given by them in the past. From there, we tried to anticipate together possible gamification-based strategies useful to offer solutions from a more playful perspective than the ordinary one. The main output of this phase was the formalization of eight gamification-based learning activities design patterns.

### *Phase 3: Pilot implementation and evaluation*

This phase was devoted to the pilot implementation and evaluation of the eight design patterns in several courses of

different disciplines and degrees. This allowed us to refine the initial drafting of the design patterns and to exemplify specific aspects of its application based on the interventions done.

#### *Phase 4: Result analysis*

Finally, results of all pilot implementations were analyzed in an integrated way, with the aim of elaborating conclusions, both on the effectivity of the design instrument elaborated (template) to support the development of the gamified learning activities design patterns and the utility of the design patterns to solve the identified problems as well as to enhance the learning process. With this purpose, an on-line peer assessment process of the written design patterns was instrumented and a closing meeting with participant teachers in the project was carried out.

### V. A SAMPLE PATTERN ON STUDY SELF-REGULATION

In this section, a pattern for studying self-regulation, selected from the seven patterns that were developed during the aforementioned project, is presented. The list of developed patterns follows:

- Team Building: Improving the team building process.
- SCORE: Assessing teamwork.
- D-BATS: Encouraging fruitful on-line discussions.
- Agilewiki: Helping teams to organize a wiki.
- Feed Me!: Improving peer feedback.
- FeedQuest-FeedBack: Giving sense to feedback.
- The habit becomes the milestone: Encouraging self-regulation.

Although all eight patterns were designed following the same methodology and were piloted in real contexts, in this paper we have selected the last one ("The habit becomes the milestone"), as it tackles a transversal problematic; study self-regulation. This pattern can also help better exemplify how to follow the template presented in Section III, since it is based on a very common gamification approach. The goal was not originality, but practicability.

#### *A. Name and Context*

**Name:** The habit is the milestone: strategies for encouraging study self-regulation.

**Context:** A student faces the challenge of scheduling and organizing the time dedication in a virtual education, based on the provided deadlines for delivering the course learning activities.

#### *B. Problem statement*

The lack of self-regulation skills for learning purposes or other personal factors (e.g. little availability of study-time, irregular time dedication, not needing to obtain the degree in a specific period of time) can make students feel lost, overwhelmed and having troubles for organizing themselves for carrying out the learning activities.

#### **Detailed description:**

Learning on-line requires from students to autonomously plan, organize, monitor and evaluate their learning processes. Students should anticipate to deadlines and organize their work in tasks to be able to deliver the expected learning products on time and with the desired level of performance. For some students, the self-regulation skills are automatically activated when performing learning activities, however, some other require some guidance to build the strategies for properly organizing their study time dedication. Low time management skills can lead students to frustration when trying to perform and deliver the learning activities and can be one of the influencing factors for students' drop out.

#### **Forces:**

- The student ability to periodically dedicate a variable amount of time to study.
- Having a constant study habit, or not.
- The need to get a degree within a specific period of time.

#### *C. Proposed solution*

To use a quest-based approach, under a fantasy scenario, to control scheduled tasks. Students control avatars or player characters that improve as they complete tasks. Or suffer the consequences when they don't.

#### **Actions to motivate:**

- Assign tasks to their schedules.
- Periodically supervise the development of the work plan.
- Mark tasks as completed (or not) as the course progresses.

#### **General description:**

Following SPARC's three viewpoints, we structure the description making sure that we specify the metaphor, rules and tool.

The underlying **metaphor** for this pattern is based on the idea that students are characters into a fantasy world. The daily tasks are missions that must be solved in order to overcome the obstacles or prosper on the characters.

On regards to the **rules** that govern this scenario, at the start of the course each student chooses an avatar, and it is his/her responsibility to make it evolve through tasks completion. Progress is measured based on different parameters, such as experience points, health or gold. The completion or not of each task has an effect on these parameters, with rewards (e.g. experience and gold) or penalties (health loss, until the character might die). Gold can be spent for personalizing the character, and experience points level up the character, unlocking extra features. Given that this is a self-regulation activity, it is based on the assumption that students should be honest and reflect on whether their tasks have been completed or not.

During the course, the teacher proposes different kinds of tasks, which students schedule this themselves. Depending on task type, its impact on the student avatar's parameters differs.

For example, the teacher can organize tasks into the following five categories:

- *Transversal tasks*, which can be done at any time and repeatedly. They can be positive (e.g. participating in the course forum), which results in a reward, or negative (e.g. postponing the deadline of a task), which carries a penalty.
- *Periodic tasks* are repetitive tasks that must be performed under schedule (e.g. accessing to the virtual classroom twice a week or investing 15 daily minutes in searching information sources). Failing to complete them incurs in a penalty.
- *To-do tasks* are specific ones linked to a learning activity (e.g. reading an article or accessing to a website). They are not repeatable and always provide a big reward when completed.
- *Collaborative tasks* are related to the social distribution and completion of tasks, being an advanced level of self-regulation. The teacher can propose a set of group work tasks and students distribute these tasks within the group, succeeding (and being rewarded as a group) if they are completed on time.
- *Free tasks* are created by the student, instead of being proposed by the teacher, acting as some kind of wildcard. The name of these tasks can be shared with peers, in order to inspire them.

Each student should organize these tasks into her or his calendar or planning table. To this aim, the student should do four actions: analyze, plan, monitor, and evaluate. S(he) should analyze what tasks must do to pass the course and for what deadlines. Based on this information, s(he) should plan how to schedule these tasks over the time. As the activity progresses, the student should monitor the success on tasks completion and make the necessary adjustments for improving in next tasks. Once the activity finishes, s(he) should evaluate the goals achievement aiming to improve in next activities.

During the completion of tasks, the teacher just has a general view of the characters evolution, not knowing the success for each individual task. Such information is only visible to the student. This reinforces the self-regulation skills, as students are responsible for their characters and their progress.

Finally, on regards to the **tool**, there are several that can be easily adapted to this pattern, such as [19], [20], since it is a common one in gamification-based approaches. Between them, we propose to use Habitica (see Figure 2). Students can organize their course or activities' tasks and evaluate the level of achievement in relation to the defined milestones. Four types of eligible tasks are available in this tool: habit (transversal tasks), daily (periodic tasks), to-do (specific tasks to carry out), and missions (collaborative tasks). For each task, the level of difficulty has to be indicated (e.g. easy, medium or high). The level of achievement makes students gain experience or lose health. When a user completes a task, s(he) wins coins. These coins can be used to buy rewards. Each student creates an avatar. The users can raise levels and unlock

features for customizing their avatars. The teacher can follow the students' progress through the evolution of their characters. However, s(he) cannot know the level of achievement, either which tasks have been, or have not been, developed.

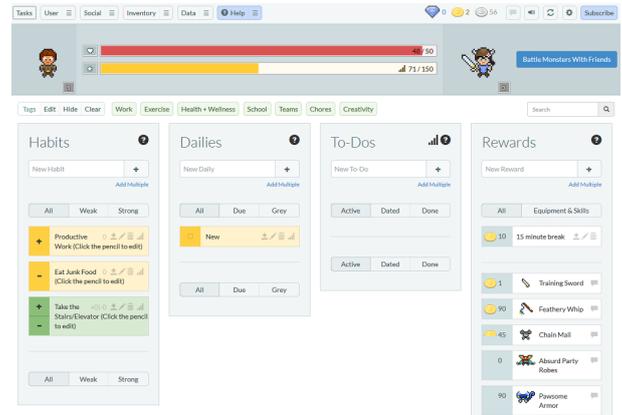


Fig. 2. Screenshot of Habitica's main player screen.

#### D. Evaluation metrics

The chosen evaluation metrics are:

- Students self-evaluation regarding their acquired habits (questionnaire).
- Teacher's opinion on the usefulness and difficulty of the pattern and the gamification dynamics.
- The number of students involved.
- The number and variety of tasks created by the students.
- Scores achieved (avatar evolution)

#### E. Pilot Results

This sample pattern was piloted in the "Information Sources I" course, from the "Information and Documentation Degree" at UOC. From 12 enrolled students in the course, four participated in the pilot using Habitica. The pattern was implemented in one course's activity that lasted 20 days and was split in 30 tasks: four transversal tasks (e.g. elaborate a calendar incorporating the activities' delivery dates), three periodic tasks (e.g. annotate the daily information sources used), 18 to-do tasks (e.g. to read the module 3), and five free tasks. Collaborative tasks were integrated into the to-do tasks.

At the end of the pilot, a questionnaire was passed to the students and instructors. The surveys consisted of 7-8 items referred to the level of satisfaction with the proposed strategy, the usefulness of the strategy for promoting students motivation and participation, the utility of the strategy for improving classroom dynamics and the learning activity, the difference between the group of students who participated in the pilot and the rest of the students in the course, and the perceived level of difficulty of the strategy and the tools and resources proposed. The surveys items consisted of statements for responses on Likert scales of 15 (labeled from strongly disagree to strongly agree). The results indicated that they were satisfied with the strategies implemented for the course's

activity. In fact, the students asked to repeat the gamification process during the third activity of the course.

## VI. CONCLUSIONS AND FURTHER WORK

In this paper, we have proposed a learning design pattern template that can be used to steer the design process of gamification-based activities. This template is accompanied with the methodology used to fully develop a design pattern, from the problem definition to deployment and piloting. We also included a sample pattern to better clarify the explanations, between several developed during this project.

From our experiences during the pattern definition process and after the pilots, we can extract some insights. On the one hand, it was of great help to integrate students and assistant teachers during the problem identification process. Contrasting their points of view regarding the problematic experiences in the learning and teaching practice helped us to delimit and better parameterize the problems and therefore also the possible solutions. This co-design process was also useful in a later stage of patterns definition, to check the perceived easiness of understanding and of application of an specific design pattern proposal. On the other hand, during the pilot implementation of the patterns, we found they could work better when applied along the full semester, instead of single activities for very short periods of time. Its application over a longer period of time would allow a better preparation, familiarization with the proposed dynamics and tools and, therefore, a greater use of the pattern.

Also, in courses with many students, we found out that scaling must be a factor to be considered in the pattern. On that regard, taking some time beforehand to consider which tools are available that allow managing a large number of participants and processes in a more simple way, instead of just providing a high level explanation, could be of help. In this sense, although our contribution is essentially methodological, we acknowledge the importance of having adequate tools for the application of most patterns.

Another interesting reflection has to do with the optionality or obligation to take part in the gamification dynamics. We started from the idea of guaranteeing the optionality of the students in deciding whether to participate or not, however we have observed that when the pattern is not applied with the whole group, it is more difficult to take advantage of it or to assess the extent to which it is useful to solve the original problem. Rewards are also another critical aspect. It is hard to find motivating aspects beyond the increase in the grade (something that we wanted to explicitly avoid). This could be solved for instance with a badges system. Anyway, in general the students who participated did so because the dynamic itself and not so much because of the rewards.

Nevertheless, the results of the teacher and students' post-pilot questionnaires indicated that they were mostly satisfied with the strategies implemented for each course activity. In fact, in some cases where the pattern was relegated to a single activity, the students asked to repeat the gamification process during other activities in the course.

Now that the pilots are over, further work includes running a second round of discussion groups in order to further refine the design patterns so they can be easily understood and deployed by teachers who did not participate in the project. We are also looking forward to creating new gamification-based learning activities patterns that try to solve other recurring problems detected in different courses at our institution.

## ACKNOWLEDGEMENTS

The authors would like to express their gratitude to all participants (assistant teachers, students) during the problems identification process and the pilots.

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