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Gamification of Business Process Modeling Notation education: an experience report

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ABSTRACT

Business Process Modeling (BPM) is a skill considered fundamental for computer engineers, with Business Process Modeling Notation (BPMN) being one of the most commonly used notations for this discipline. BPMN modeling is present in different curricula in specific Master's Degree courses related to software engineering, but, in practice, students often underperform on BPMN modeling exercises due to difficulties in learning good modeling practices. In recent years, more and more fields of computer science have employed gamification (the usage of game elements in non-recreational contexts to gain benefits in terms of interest, participation, motivation, and enjoyment) with positive results during both development and teaching processes. Thus, we have developed a platform for BPMN modeling that employs gamification mechanics to facilitate learning good modeling practices with mechanisms such as rewarding good modeling solutions and penalizing less correct ones, with a dedicated feedback mechanism that maps correctly modeled elements to the corresponding concept. A preliminary laboratory experiment has been conducted with students of an Information Systems course to evaluate how students receive the mechanics and if there may be benefits in using a gamified environment for teaching process modeling throughout an entire course.

CCS CONCEPTS

• **Applied computing → Computer-assisted instruction**; **Interactive learning environments**.

KEYWORDS

Education, BPMN Modeling, Gamification, Process Modeling, Computer Engineering

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1 INTRODUCTION

Business process modeling is a necessary skill for computer engineers, as it allows them to understand and analyze organizational processes, which in turn allows them to make reasonable and informed decisions and identify possible improvements in the processes they work on [8]. Being able to correctly model business processes is a skill that translates to computer engineers being able to design effective processes, evaluate existing ones and support business needs. One of the most commonly used notations for learning how to model and analyze organizational processes is Business Process Model and Notation (BPMN), a standard for the graphical representation of business processes that makes use of flow-charting logic to define the logic behind a process at a both high and low level; it is particularly effective at specifying the sequence of actions that compose a business process, as well as specifying the actors that execute each step. However, over the years of BPMN modeling courses, we observed students struggling to comprehend modeling business processes with good BPMN practices, leading to poor evaluations. Gamification, as first defined by Deterding et al. [5], consists of *the use of game design elements in non-game contexts* in order to increase user motivation, interest, and participation in both industrial and academic contexts. The main goals of gamification are to increase involved users' productivity by stimulating positive feelings through an experience capable of engaging them [6]. Gamification-based approaches have some important advantages from the psychological user-experience perspectives in non-ludic activities, such as increased motivation, focus, and engagement, but also better performance and higher efficiency. This paper describes the first experiences in introducing a gamified learning tool in a BPMN modeling course. The tool makes use of an evaluation engine that gives feedback depending on how well a student has modeled a BPMN diagram that represents a business project, with the feedback including rewards for good practices and penalties for incorrect modeling structures. A laboratory experience has been conducted with students of an Information Systems course to assess how students perceive the gamified learning experience, in order to have a reasonable starting point for further restructuring of the course and enhancement of the tool features. The remainder of the paper is structured as follows: Section 2 provides a background explanation on gamification and pre-existing gamified tools for teaching modeling languages, Section 3 describes the gamified elements of the tool, as well as its evaluation engine that allows for the implementation of said elements, while Section 4 describes the current course structure and how we plan to improve future editions using the tool. Section 5 describes a laboratory experience where the tool was used by students and, lastly, Section 6 discusses the lessons learned from the experience, as well as future plans regarding the tool.

2 BACKGROUND AND RELATED WORK

We provide here a brief description of the main mechanics used in gamification, followed by a discussion of pre-existing works that describe the application of gamification to teaching BPMN and other modeling languages.

2.1 Gamification Mechanics

Some of the most commonly used Gamification mechanics compose the so-called *PBL Triad*, which is made up of *Points*, scores obtained by the participants to the gamified activity, *Badges*, distinctive elements awarded to participants after reaching relevant milestones that help to customize the gamified experience, and *Leaderboards*, rankings of all the participants that encourage participants by stimulating competition. Other relevant elements include:

- *Prizes*, items earned by users after completing a specific goal. These items may be tangible, such as real-life rewards or extra grades at the end of a course, or intangible such as in-game currencies or rewards.
- *Progress Bars*, visual indicators of a user's progression regarding a specific task.
- *Levels*, numerical indicators of a user's skill level, usually connected to an experience mechanic, with experience being earned after specific milestones.
- *Challenges*, complex tasks that offer a greater sense of accomplishment if successfully completed, due to the skills they require. The addition of a narrative aspect turns challenges into a different element named *Quests*.
- *Avatars*, visual representations of users in a gamified system. They allow participants to customize their own experiences and freely express their personalities.
- *Feedback*, mainly used in gamified learning systems, consists of mechanics such as interactive tutorials, error warnings, suggestions, and indications of correct solutions. The usage of feedback allows for a broader range of students to easily learn from their actions.
- *Penalties*, or negative responses can act as a different type of motivator by making users more focused on their actions and incentivizing them to improve them, in order to avoid losing points.

2.2 Related Works

There are a few examples of gamified tools employed for assisting the learning of modeling languages discussed in the current research literature. A first example of such a tool is Papygame by Bucchiarone et al. [3], a plugin for Papyrus[1], a modeling tool developed by the Eclipse foundation which offers support for many different modeling languages. Papygame offers various games, corresponding to different modeling tasks, which go on until they are either completed successfully, awarding points and in-game progress, or failed, in which case there is no advancement and a feedback screen listing all the errors made during the game is shown, facilitating the learning process. This is due to the presence of a separate gamification engine that keeps track of players' statuses and defines the rules of each possible game; the modular structure of the tool also allows the definition of new games other than the existing ones. The authors mention that the plugin has been the object of a preliminary evaluation with students focusing on its usability and user experience, which has shown promising results. Cosentino et al. [4] also propose a plugin for the Papyrus tool: their work focuses on a gamified experience based on increasingly difficult levels, with these levels being composed of various groups of topics that represent different modeling concepts. Completing the predefined tasks associated with groups of topics awards users achievements and in-game rewards. The plugin is also notable for being a rare example of a gamified tool that focuses part of its efforts on cheating prevention by blocking the manipulation of user details, a feature that is often overlooked in other common gamified tools. Unfortunately, to the best of our knowledge, there is no documented use of such a plugin in actual educational environments. Both of these works represent examples of gamified tools used for teaching modeling languages, but they, unfortunately, do not support the BPMN modeling language, as the platform they are built on does not offer a way to model BPMN diagrams. A different work that comes closer to the scope of this paper is represented by BPMN-Wheel: the work by Kutun et al. [7] differentiates itself from the two plugins cited above as it focuses on actually teaching BPMN modeling but, most importantly, because it consists of an applied game rather than a gamified tool. Despite that, it is still notable enough to be mentioned as an example of a strategy used for aiding the teaching of the BPMN language. The actual game consists of a board game played by two teams where teams take turns spinning a wheel that has them answer theoretical questions, which in turn awards them in-game currency, the right to obtain process elements, or to attempt modeling an entire process. The team that is able to model correctly the target process is the one that wins the game. The authors conducted an experiment using the game and found that it brought improvements in the quality of the processes modeled before and after using the tool; particularly interesting is the usage of both competition and cooperation, elements which are absent in both previous works. Currently, it seems that there are no gamified tools that focus especially on teaching the BPMN modeling language to students, as current existing works in the state of the art either focus on different modeling languages or define a different approach (applied game rather than gamified platform).

3 TOOL FEATURES

The tool employs four gamified mechanics (*Rewards*, *Penalty*, *Progress*, and *Feedback*) in the form of an evaluation system that checks whether diagrams modeled by students follow rules that define how specific process parts have to be modeled, grading them on how many parts are modeled correctly. Correct modeling awards points, depending on the difficulty of the modeled part, and these points can be spent to purchase pieces of a puzzle; this mechanism composes the *Rewards* of the tool, as improving the solution leads to higher points and more puzzle pieces to purchase. In a similar way, errors lead to a *Penalty*: the points that would have been obtained

[1] https://www.eclipse.org/papyrus/ (accessed on 17 March 2023)

Figure 1: Scores section of the tool page

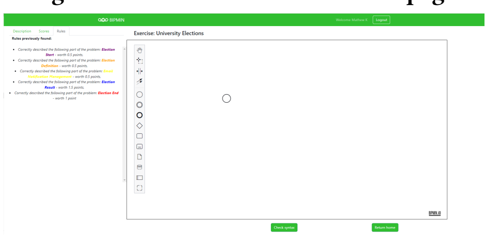

Figure 2: Tool homepage with the section displaying identified rules on the left side

for modeling correctly a specific part of the problem are subtracted from the student's grade (a separate score, disconnected from the points earned which can be exchanged for puzzle pieces); penalizing wrong attempts can be thought of as a motivating influence in learning. The tool also allows students to gauge their *Progress* with a dedicated bar that shows the correctness (percentage of respected rules over the total number) of a submitted solution. Figure 1 shows how these elements are visible in the tool, displaying the puzzle with some pieces already purchased, the progress bar showing the correctness of the last evaluated diagram, and indicators for the current grade (which is reduced in case of penalties) and the available points (which increase when modeling correctly new problem parts). Lastly, the implementation of the *Feedback* mechanic is what ties all the above elements together: checking the correctness of a diagram displays all the parts that are modeled correctly and those that are still missing, with the former being colored in a specific way. All parts that have been modeled correctly at least once have their own section in the tool menu, allowing students to review them, as is shown by Figure 2, where the specific section appears on the left side. As a way to reinforce the feedback, and actually help students understand which parts of their diagram represent which parts of the problem, elements in the diagram are colored with the color corresponding to the part they represent; Figure 3 shows an example of diagram with some elements having the same

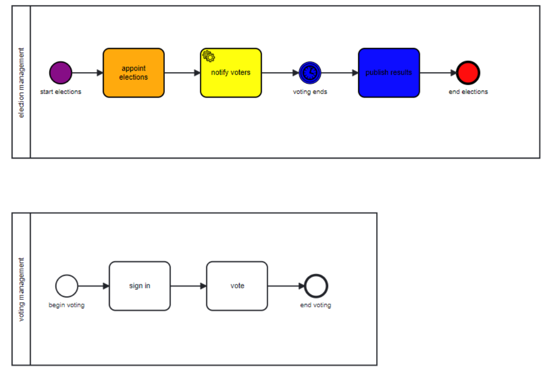

Figure 3: Updated diagram showing the correctly modeled parts

color of the parts that appear in the rule section. The evaluation engine composes a fundamental part of the entire tool, as it serves as the foundation on which the gamified mechanics are actually implemented. The way the evaluation engine works is by analyzing the various elements that compose a diagram and checking for the existence of elements, or group of elements, that satisfy a specific set of criteria defined via *JSON* objects; these criteria define which properties an element must have to model correctly a specific part of the problem it is part of. Each JSON object that defines a part of the problem specifies a type of BPMN element: the diagram must contain one element of said type with properties such as having a name containing at least one string out of a defined list or being part of a pool whose name must also contain at least one of its own mandatory strings. Other requirements define the necessary element's relations with other elements: the element required for a specific part of the problem may be connected to other elements that must also exist with their own set of properties; this means having, in the JSON structure, inner objects that specify the other elements of the diagram. These inner objects may also represent other parts of the diagram, with their own set of interconnections corresponding to other separate objects. The evaluation engine allows for the definition of multiple exercises supported by the tool: teachers only have to define the *JSON* objects that represent the various elements of a specific solution in order to support different exercises.

4 COURSE STRUCTURE AND CHANGES

In addition to creating the tool for gamified BPMN education, we also updated the structure of the course with respect to previous years. We have introduced a set of practical laboratories in which the students can solve exercises regarding the topics faced in the theoretical lessons, by using an already existing tool, Signavio Academic[2]. The exercises are organized into quest lines. While in the current version of the laboratories it is not possible to provide any feedback given the high number of enrolled students (300+ per year), with the usage of the tool the students can receive live feedback about how well they are performing in the exercise. This can be considered a major enhancement in the course experience provided to the students. The course also includes an optional project

[2]https://www.signavio.com/ (accessed on 14 April 2023)

Table 1: Mapping between gamified elements and course behaviors

Game Element	Students'/Teachers' Behavior
Rewards	Comparisons performed by students over the different grades obtained
Penalty	Lower scores assigned to the optional project in case of mistakes
Progress	Sequence of exercises provided in consecutive laboratories of the course
Feedback	Solutions of laboratory exercises explained in classroom, corrections given to exercises of the optional project

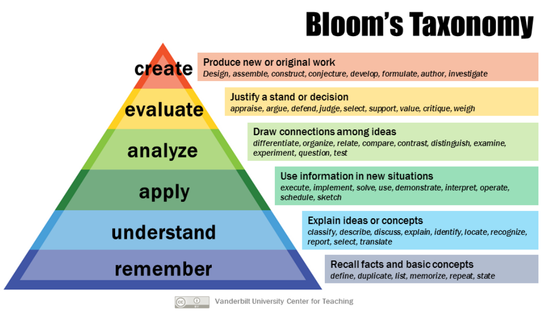

Figure 4: Pyramid structure displaying Bloom's taxonomy.[2]

that involves all the different topics and allows students to obtain additional points for their final exam grade. As a motivation behind the development of this tool, we performed a mapping between the gamified elements and behaviors typically found during the course's execution, hoping to understand where a gamified tool could be used to bring some benefits. This mapping can be found in Table 1.

As we plan to improve on the tool for future usage in the next edition of the course, we intend to implement competition via a leaderboard and an overarching sense of progression with unlockable elements after successfully completing challenges represented by the different laboratory exercises, as the way the course is structured lends itself to a challenge with increasing difficulty culminating with a so-called *final boss*, represented by the optional project. We have applied the concepts defined by Bloom's taxonomy [2], and more specifically the revised version by Anderson et al. [1], of which we offer a visual representation on Figure 4, to the practical activities offered by the course, that is, laboratories and the optional project. We can say that the way the course has been offered until now touches up to the third level, *Apply*: students satisfy the first two levels (*Remember* and *Understand*) by following the theoretical lectures and studying the concepts explained, and then put these concepts in practice by solving laboratory exercises. The implementation of a feedback mechanic in the gamified tool may prove to be beneficial by allowing students to reach the fourth and fifth levels of the taxonomy, *Analyze* and *Evaluate*: by receiving detailed feedback on which parts of their modeled solution are correct students would be able to improve their understanding. The current implementation of the feedback mechanic is a first step in this direction, with the coloring of different elements corresponding to specific parts of the process that have been modeled, but there is still room

[2]Source: https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/ (accessed on 17 March 2023)

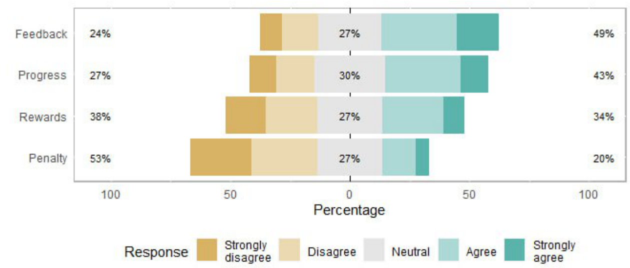

Figure 5: Distribution of the answers related to the gamified mechanics

for improvement: detailed feedback that lists reasons explaining why specific parts of a model are correct or wrong would be even more effective in aiding students in learning BPMN modeling.

5 LABORATORY EXPERIENCE DISCUSSION

To assess how the tool could be received by students, we set up a preliminary experience with the tool during a laboratory session of an Information Systems course: the experience consisted of students performing two modeling exercises with two versions of the tool, one with the gamified mechanics described in this paper and another without gamification, which employed a simple check on whether the diagram respected syntactic rules for BPMN modeling. After the experience, we collected students' opinions with a survey composed of twelve questions asking students' opinions on the four gamified mechanics present in the tool (*Progress*, *Feedback*, *Rewards* and *Penalty*), as well as two open questions where students could report any issue found during the experience, as well as any suggestion they had to improve the experience. For each mechanic, we asked three questions, focusing on the student's opinion regarding appreciation, influence on the experience, and perceived usefulness of the mechanic. We present the distribution of answers to these questions in Figure 5: to compute the distribution we have considered, for each participant, the rounded mean of the answers given to each question for each gamified mechanic. The total number of participants in the experience was 200 students, with 199 answering the questionnaire. The most evident result appears to be widespread disapproval of the *Penalty* mechanic: 53% of the participants have assigned a low average grade to questions related to this mechanic; comparing this distribution to the ones computed for the other three mechanics shows that students generally do not appreciate being penalized repeatedly for their mistakes. Distributions related to other mechanics show better results, however: the *Feedback* mechanic appears to have been particularly well received, with a total of 49% of participants answering positively to questions related to it on average. The answers to the two open questions have been grouped based on the topic they touch, following a strategy based on open coding the answers, ignoring those that had no relevant information. An analysis of these answers confirms that the penalization of wrong modeling choices has not been appreciated by students: a total of 14 participants have left comments that touch on the specific penalty issue, asserting that it was seen as a frustrating feature, or that the penalty system could be revised so that subsequent attempts with the same amount of errors were not penalized.

Moreover, 48 participants have mentioned in their comments details about how the system could be improved by allowing multiple correct solutions: we can link suggestions that mention these two topics together and assume that receiving negative feedback due to the evaluation system not accepting solutions that differ from the one expected can be a source of frustration. It is reasonable to assume that if there were multiple solutions allowed by the system there would have been fewer negative comments about the lack of said feature, resulting in turn in fewer students being penalized, and thus a better appreciation of the penalty mechanic, as students would not see a reduction in their points for every attempt submitted. Moreover, there are 17 comments that mention the need of improving the feedback system, together with 15 other comments where students mention how some kind of hint system would be an improvement: these comments can be seen as part of the same reasoning. More detailed feedback would be more valuable, as well as make the penalty less frustrating, as students would easily understand what they are doing wrong; the presence of hints would also reduce the number of errors made, leading to less penalization. These findings show that using penalties for a gamified learning tool may not be the best approach, meaning that future plans for this tool will have to either remove the concept itself, allow multiple correct modeling options, or rework the evaluation engine in a different way. A possible alternate implementation of the evaluation engine would go the opposite way, defining typical errors and penalizing students only if they submit diagrams that contain these errors.

6 CONCLUSIONS AND FUTURE PLANS

This study described a tool that makes use of gamification principles applied to Computer Engineering education, regarding the practice of teaching BPMN modeling. The tool employed mechanisms such as visual feedback, rewards for good practices, and error penalization to improve student interest and motivation, as well as an evaluation engine used to actually allow these mechanics to actually be enjoyed by students. A laboratory experience was then conducted to evaluate the students' perception of the gamified mechanics and general opinions on the tool: 200 students of a Master's Degree Information Systems course, took part in the experience, solving a BPMN modeling exercise with the tool's assistance. Open-ended questions identified the penalization mechanic as the weak link of the tool, which combined with an evaluation engine with a limited amount of allowed correct answers, may be the cause of the not exceedingly positive distribution of answers. It is reasonable to say, however, that the tool may still be used in a classroom environment in the future, as we plan to improve its implementation by reworking the evaluation engine by either allowing more correct solutions or by changing its behavior to one that looks for wrong modeling practices and penalizes them. To conclude our discussion, we summarize the main lesson that we learned from the laboratory experience:

- Using a tool as support for laboratory practices can be effective in making performing exercises interesting and appealing, as well as increasing students' absorption in the activity, compared to regular exercise solving.
- A gamified tool leads to higher involvement compared to traditional laboratory activity. As a consequence, the number of participants in the experience was way higher than the average number of participants in general laboratory activities.
- Live feedback allows for more effective learning, as students are able to understand instantly the errors of their solution, rather than having to wait for a teacher to be available to answer questions. In turn, this means that laboratories with many participants can be understood even if the available teachers are unable to address the questions asked by each student.

There are also, however, some issues that have emerged from the experience which must be mentioned:

- Live feedback, while effective, does not consider all possible modeling solutions and is not trivial to define, meaning that edge cases will prove to be a relevant issue.
- Transition from a standard tool to a gamified one may not be simple, as the aversion to change is something that must be considered; the usage of gamification may also mean that the mechanics implemented in the tool may lead students to model in incorrect ways that, however, are recognized correctly by the tool.

As we intend to make use of the tool during the entire duration of the upcoming edition of the course, we also plan to insert new gamified elements to improve the experience, such as the usage of competition mechanisms such as leaderboards, as well as define the presence of an evolving quest line around the various topic of the course. We believe that continuous usage of a gamified tool that is less strict in its evaluation and makes use of common concepts of gamification such as competition and user progress will yield positive results in future editions of the course. To this purpose, we also plan to perform a thorough experiment where we will evaluate whether the usage of gamification can lead to improvements in students' performances.

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