Badges for all: using gamification to engage HCI students

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ABSTRACT

Keeping students attentive and participative is a challenge in the context of higher education. Considering the computing field, its inherent complexity, alongside a scenario where the classes are at night, engagement is even more challenging. To deal with these issues, several methodological alternatives have been discussed, including gamification. Trying to promote student engagement, we used a set of 15 distinct badges, related to different kinds of activities (individual, in groups, at home, in class, among others), in an HCI undergraduate course, with 46 students, during an entire semester. We collected data about earned badges, user satisfaction, as well as their grades and class attendance. Our main results are related to the students' engagement and satisfaction, adding new evidence of the gamification effectiveness in the educational context, as well as its possibilities of use in an HCI course.

CCS CONCEPTS

• Human-centered computing~Empirical studies in HCI; • Social and professional topics~Computing education

KEYWORDS

Gamification; student engagement; HCI education

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1 INTRODUCTION

Engagement is one of the continuing challenges in education [7]. According to Morgan et al. [15], "students who are engaged actively participate as partners in the learning process. (...) Conversely, students who are disengaged tend to experience feelings of isolation and become demotivated, and are therefore at greater risk of dropping out of their courses". Considering the computing field, its inherent complexity, alongside a scenario where the classes are at night, engagement is at the same time more challenging and more necessary.

In order to encourage student engagement as well as to develop essential skills needed in the computing field – such as teamwork, verbal and written communication, time management, problem-solving, and critical thinking [9][12][15], several alternatives to traditional classes have been proposed. Problem and project-based learning, inverted classroom, peer instruction, games, and gamification are some of those methodological alternatives.

In the research here described, we used a set of gamified activities, involving not only the topics discussed in class but also an attempt to develop some of the before-mentioned skills, aiming at increasing students' participation. These gamified activities were applied in an HCI undergraduate course comprising 46 students during an entire semester. The game element used to gamify this course was the badge. The students could earn a set of 15 distinct badges throughout the semester, culminating in earning two points in the final exam (final bonus).

As literature claims for more empirical evidence on the use of gamification [4][5][11], during the course, we collected data about the earned badges, user satisfaction, as well as students' grades and their attendance to the classes. Our main results are related to the students' engagement and satisfaction, adding new evidence of the gamification effectiveness in the educational context, besides its possibilities of use in an HCI course.

In the next sections, we present some studies used as background and related work, followed by the methodology we adopted, the obtained results, our discussion, and final considerations.

2 GAMIFYING EDUCATION

Deterding et al. [6] consolidated the definition of gamification as "the use of game design elements in non-game contexts", emphasizing the interest of using it to "motivate and increase user activity and retention". The authors cited interaction design and digital marketing as fields of application, but education is also an open and growing field [1][7][8][13][16]. According to Dichev and Dicheva [7], gamification is an approach used to motivate and

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engage students, which is one of the greatest challenges in education.

To Denny [4], "despite the growing utilization of badges, there is little empirical evidence to support their effectiveness at motivating and engaging users". Years later, Denny and colleagues [5] continued to emphasize the lack of empirical studies on the matter, presenting some of the methodological limitations found in the literature review performed by Hamari et al. [11]. Among the limitations highlighted by the latter, we could observe small sample sizes in some studies, multiple affordances (points, leaderboards, badges, and so forth) investigated as a whole, and short investigated timeframes.

Denny [4] presents a large-scale study, involving a class of more than 1000 students, in which half of them had access to a badge system (being able to earn up to 22 distinct badges for their contributions and activities) associated to an online learning tool. The results indicate the positive effects badge-based achievements have on user participation.

The 22 badges used by Denny [4] on the online learning tool are classified in three categories - basic, standard, and elite - related to the level of difficulty required to earn each of them. Dicheva et al. [8], in a systematic mapping study about the application of gamification in education, used what they called educational gamification design principles in order to review the use of game elements in gamified educational contexts. They present 15 design principles, some of which in a more generic sense (applicable to every game element), such as goals, challenges and quests, customization, and freedom to fail; and others which were more specific to badges (which is our case), such as feedback, competition and cooperation, and visible status.

In this work, we attempt to contribute with the empirical studies in this field, focusing on one unique element (the badges), during the entire observed HCI course. We shall, then, present the study done and compare our results with the research mentioned in this section.

3 METHODOLOGY

This is a descriptive investigation [14], based on observation and the capture of quantitative and qualitative data. In the next sections, we present our research questions, the badges the students could get during the related activities, the students' profile as well as the course they were enrolled in, and the collected data (collecting ways and types).

3.1 Research Question

Our main research question is **How does the use of badges in an HCI course contribute to student engagement?** Associated with this question, we also aim at observing which kind of gamified activities foster more participation, the students' satisfaction with those gamified activities, and if we could notice any difference in the grades of the most participative (gamified) students.

3.2 The Context: Course and Students

The course we observed is part of a Software Engineering undergraduate Program, whose classes begin at 5:35 PM and end at 10:45 PM, from Mondays to Fridays. This program includes two courses in the HCI area, namely Fundamentals of HCI, a 4-credit mandatory course offered in the 3rd semester, and Interaction Design, a 2-credit course that is also compulsory, offered in the 4th semester. In this paper, our focus is on Fundamentals of HCI. This course aims at introducing the HCI area, tackling its main concepts and theories, as well as different evaluation methods on the quality of use and the principles of the interaction design process (Table 1 presents the main topics of the course) [18].

Table 1: Main topics of the course

Course unit	Main topics
HCI context	goals multidisciplinarity evolution ethical aspects professional profile
HCI principles	basic concepts quality of use cognitive, cultural, and social aspects theoretical approaches
HCI evaluation	planning evaluation methods
Interaction design (first phases)	design processes data gathering for requirements data analysis

This course schedule is on Tuesdays and Thursdays, from 7:30 PM to 9:00 PM. The activities we present and discuss are related to the course offered in the first semester of 2019, comprising 64 class hours, divided into 32 encounters (twice a week - with 16 weeks in total). We had 46 students who attended the entire course (49 students started attending the classes, but three of them dropped out in the middle of the course and, therefore, were not considered here), being 41 male and 5 female students (a typical distribution in this program).

3.3 The Badges

In the set used during the course, there were 15 distinct badges, from which the students could earn one or more of each type. At the beginning of the course, we discussed the general rules related to the badges in gamification, as follows.

- The set of badges was divided into two subsets: regular ones and extra prize ones. The regular badges were the ones all

students could get (regardless of winning or competing). The extra prize was related to winning some contests, achieving the best grades, among others.
- As not all students would earn the extra prize, the final bonus would only consider the regular badges.
- The final bonus:
  - The students who earn 80% (or more) of the regular badges will receive two points in the final exam (they could eliminate one of the five questions of the exam, at their discretion)[1];
  - The students who earn only 50% of the regular badges will receive a tip[2] during the exam;
  - The students could replace a missed regular badge with an extra prize one, to the final bonus account.
- The students able to get 100% of the badges shall receive a "golden badge", representing their great achievement (as well as an "edible" prize).
- The participation in the gamified activities was voluntary.

Table 2 presents each badge, classified by their type (regular or extra prize), their related content, the activity that should be performed to earn them, the activity modality (individual, pair work, or group work), and if most of the activities should be performed in class or at home.

The badges were first designed to be digital. However, at the beginning of the semester, one student suggested that they could be "physical", and the other classmates agreed. This way, we printed the badges in the form of stickers. Figure 1 presents the complete set of 15 badges. They were originally printed in Portuguese. The ones you see below have been translated into English for this publication.

Figure 1: Complete badge set (stickers)

[1] All questions had the same level of difficulty.

3.4 The Collected Data

In order to discuss our research questions, we collected different data, as the number of badges earned by each student, the number of badges earned by activity, the number of badges earned by category (regular or extra prize), the number of badges by setting (in class or at home), the number of students by final bonus type (100%, 80%, or 50% of the badges), the attendance average considering the entire class, the attendance average considering the students who received the "final bonus", the attendance average considering the students who did not receive the "final bonus", the Institutional midterm course evaluation, students' satisfaction about the use of badges, the grade average considering the entire class (all semesters in which the course was taught), the grade average considering the students who received the "final bonus" (2019/1), and the grade average considering the students who did not receive the "final bonus" (2019/1).

4 RESULTS

Our results are presented considering their relations with three main observed aspects: engagement, satisfaction, and grades.

4.1 Engagement

The primary motivation to use gamification in this course was an attempt to promote student engagement. We observed, in the last editions of this course, that students rarely carried out the activities at home; for instance, the activity related to the Construction badge (the creation of scenarios considering Norman's Theory of Action) was not done at all during the last four editions of the course at least. Thus, our main research question is related to such student engagement.

Considering the earned badges, each student got at least 2 of them, with an average of 6.8 badges per student (the most "gamified" student got 14 badges). We can also analyze the badge distribution according to the prizes the students can earn. Bearing in mind that the students had to get at least 80% of regular badges to get the final bonus (2 points at the final exam), 12 students reached less than 50%, 7 got 50%, 14 got 80%, and 13 got 100%. We highlight that the students could already get the final bonus gathering 7 badges, notwithstanding we had 20 students with more than 7, representing 43% of the students, as in the study of Ibáñez, Di-Serio and Delgado-Kloos [10] where the students continue working even after earning the maximum amount of grade points.

Looking specifically at the types of earned badges (and their related activities), Figure 2 shows the badges earned in regular activities, in a total of 228, and Figure 3 presents the ones related to extra prize activities, consisting of 87 badges. As for the regular activities, we can notice higher participation in the activities done in class (Communication, Game Design, and Research), as expected, but good participation in the activities performed at home (one of our biggest challenges in a scenario of evening classes).

[2] The student chose one of the questions and received a tip related to it.

Table 2: Badge classification. (M)odality: (I)ndividual, (P)air work, or (G)roup work. (S)etting: at (H)ome or in (C)class

	Badge	Related content	Activity	M	S
Regular	Exploration	First gamified activity, not content-related.	Explore a new University building, designed to be a proof of concept to new classroom styles. Take a picture in the building and post it on the course's Virtual Learning Environment (VLE).	I	H
	Design	"Hall of shame"	Find a design problem (related or not to an interactive system), take a picture of it, and post it on the course's VLE.	I	H
	Communication	Cognitive aspects	Participate in "short games" involving the concepts of memory, attention, perception, etc.	P|G	C
	Construction	Cognitive Engineering	Create scenarios through which your classmates should map the gulfs of evaluation and execution from Norman's Theory of Action, and post it on the course's VLE.	G	H
	Great Job (Easter Challenge)	Interface redesign	Find an interactive system interface/interaction problem, redesign it, and post it on the course's VLE.	I|P	H
	Game Design	HCI Evaluation	Create a paper-based board game, related to a specific HCI evaluation topic (a different topic per each group).	G	C|H
	Research	HCI Evaluation	Participate - as inspectors - in a game system evaluation.	I	C
	Valentine's Day	HCI Evaluation	Find - good or bad - examples of one of the Nielsen's heuristics, and post it on the course's VLE.	I	H
	Cooperation	Learning Object Use	Use a Learning Object related to the HCI field (to help its refinement).	I	H
Extra prizes	Creativity	Semiotic Engineering	First, design an icon to a received functionality (that does not have a traditional graphic representation). Then, show it to the class so that colleagues should guess what it is. The winners are the groups that designed icons with the best and the worst communicability.	G	C
	Success	Miscellaneous	Voted as the best in some activities (for instance, the activity related to creating a timeline of HCI history), or grades above 9 (ranging from 0 to 10) in some given assignments.	G	C|H
	Kahoot Master	Miscellaneous	Groups that obtained the first place at Kahoot[3] contests used to review content: one in the middle of the semester and another at the end.	G	C
	Collaboration	Miscellaneous	Help colleagues and the professor during the classes, or being the first place at a virtual scavenger hunt executed during class.	I|G	C
	Fantastic!	Miscellaneous	Best grades in the assignments (grades ranging from 9.9 to 10).	G	C|H
	Attendance (100%)	Attendance	100% of attendance in class.	I	C

[3] https://kahoot.com/

Analyzing Figure 3, we observe that only one student earned the 100% Attendance badge. Considering what we know about our students' attendance (and some difficulties experienced by them related to work during the day and having some meetings or trips at the same time of the classes), we categorized this badge as "Extra prize". The course comprises 64 class hours, and the students could be absent in 25% of them, representing at most 16 class hours of absence. At the end of the course, the students had an average of 9.7 absences. If we look specifically at the students who got the final bonus (20 students), they had an average of 8 absences, and the other ones 12 absences. Of course, if the students are more present, they could get more badges. Moreover, this could also demonstrate higher student engagement in the course activities.

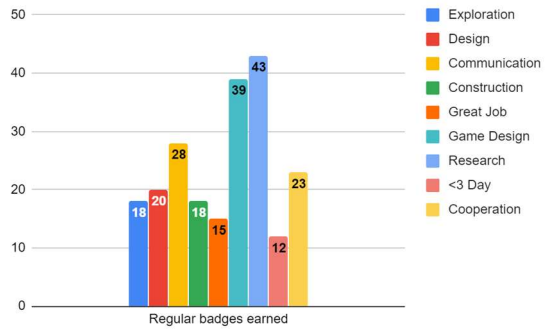

Figure 2: Number of regular badges earned per activity

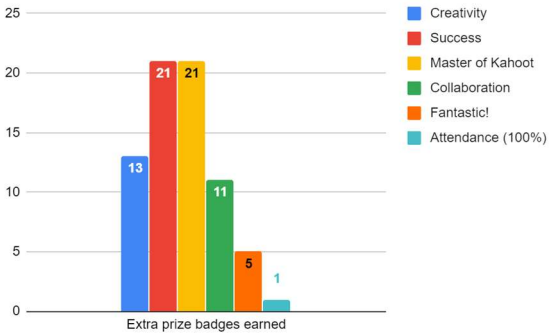

Figure 3: Number of extra prize badges earned per activity

4.2 Satisfaction

We conducted three satisfaction surveys during the course, of which two were institutional: a midterm course evaluation and a final term course evaluation. The third one was presented by the professor also at the end of the semester, and it was specifically devoted to the use of badges. Here we would analyze the institutional midterm evaluation results and the results on the use of badges. The institutional final term evaluation had only five participants and, since no one had answered the open-ended question, we decided to discard it. It is worth noting that all of them were answered in a voluntary and anonymous way.

Considering the institutional midterm course evaluation, we had 31 instruments answered, representing 63,27% of the total enrolled students (at that time, we had 49 enrolled students: two of them never showed up to class but were still listed in the rollcall, and one canceled the course some weeks later). The midterm survey has only six questions, and its idea is to give room to the class improvement still during the course execution. Two of these questions are representative of the work here discussed: the question related to the students' satisfaction considering the interpersonal relationship among the classmates and their satisfaction considering the professor's teaching action. To both questions, the satisfaction level was 4.3 (on a scale from 1 to 5, being 5 very satisfied and 1 very unsatisfied): in terms of interpersonal relationship, 28 (out of 31 participants) were very satisfied or satisfied, whereas regarding teaching action, 24 (out of 31) were very satisfied or satisfied (being 18 very satisfied). The main students highlights' were the diversity of assignments used, the use of practical activities in a dynamic way, and the idea of using badges.

Considering the survey about the use of badges, it was realized at the end of the semester. As the institutional final term course evaluation, we did not notice great student participation: 12 out of 46 students answered it, representing only 26%. Nonetheless, as this survey is specifically related to the subject, we will discuss its results here (highlighting, though, that it is not representative of the entire class).

Considering the use of badges during the course, 2 really liked it, 7 liked it, 2 neither liked nor disliked, and 1 did not like it (all the above-mentioned out of 12 respondents). Figure 4 shows the most interesting activities, according to them. They could choose more than one option, and some students chose three or four of them.

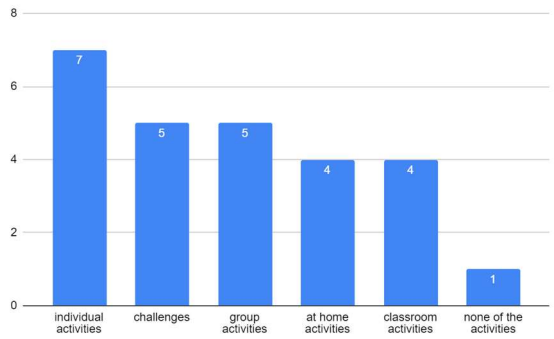

Figure 4: Most interesting activities, according to the students

When asked if badges had encouraged them to do activities that they would not otherwise do (without any associated reward), 8 (out of 12) answered yes, 3 answered no, and 1 answered maybe. Furthermore, out of the 12 students who answered the question about the motivation to participate in this kind of activity, 7 mentioned the possibility to earn the final bonus, 7 for fun (to collect badges), one "*because of the jokes*", 2 mentioned they were not motivated, one to compete with their friends, and another to

give the badges to his wife (in this question, they could choose more than one option). Considering the use of badges by other courses, 6 said they would like it, 5 were not sure, and 1 answered he/she would not like it. Some of them also highlighted the associated motivation ("*it is a good motivator*"; "*I liked it because they use gamification to encourage us to do things that would be very boring*").

4.3 Grades

Another observed perspective was about the students' grades. Trying to minimize possible bias, we took off from the final exam grades, the final bonus earned by the students (that is, we took the 2.0 points they received and we averaged the remaining amount over a total of 8 points). Thus, we have some observations on this matter.

If we observe the final exam grades of all the courses since 2016/1 (the first time the course was offered), we could notice a little decrease in it in the last three semesters (Table 2).

Table 3: Final grades in the last editions of the course (considering the 2019/1 adjustments)

Semester	Number of Students	Final Exam Average
2016/1	23	8.6
2016/2	21	9.0
2017/1	32	8.0
2017/2	17	8.6
2018/1	44	8.1
2018/2	30	7.9
2019/1	46	7.8

However, more than the grade itself, we would like to analyze the specific cases where the students received the final bonus. If we observe Table 3, we could notice that even taking off the bonus and recalculating the final grades, there is 0.5 point of difference between the grades of the students that received the final bonus (that participated more in the gamified activities) and the students that did not receive it. Of course, we cannot affirm that the increase in the grade is related to the effective participation, but it is a sign that leads us to pursue more information about that in the future, in order to deepen our investigation.

Table 4: Final Exam (F.E.) Averages in 2019/1

	F.E. Average (published)	F.E. Average (without the bonus)
Entire Class	8.0	7.8
Students without the final bonus	7.3	7.3
Students with the final bonus	8.6	8.2

5 DISCUSSION

In order to deepen the discussion about some of our obtained results, we look at them under five distinct lenses: engagement, skills, the badges, pedagogical implications, and threats to validity.

5.1 Engagement

In previous sections, we could observe the student engagement bearing in mind the number of earned badges. Considering the measures of engagement discussed by Silpasuwanchai et al. [17] - behavioral, emotional, and cognitive engagement - we could observe that the way the tasks are elaborated reflects on this engagement. For instance, the tasks in which we observed more students' involvement and interest during the classes (behavioral and emotional engagement) were the board game construction and the game evaluation. Both tasks require students' concentration and reflection (cognitive engagement), and in the case of the board games, additional studies at home are also required to complete the task. The cases that students only had to search for examples (for instance, the badges entitled Great Job or Valentine's day), were the ones with less students' participation.

5.2 Skills

Besides the gamification per se, in the Introduction, we cited some of the skills needed in the computing field. We believe we could also help the development of these skills, during our badge-related activities. For instance, teamwork was highly seen in activities such as the board game construction, the Kahoot contests, and other pair or group work activities. Verbal communication was explored during group meetings, as well as in the short games associated with the Communication badge. More than half of the activities needed to be textually described, enhancing written communication. Time management, critical thinking, and problem-solving were very important in the board game creation, as well as in several other activities.

5.3 The Badges

Analyzing our set of badges, taking into account the research done in this area, we first looked at them considering the categories proposed by Denny [4]. Our Regular category started with a basic and easily solved activity, involving taking a picture (Exploration badge), followed by standard ones. Besides that, almost all of our Extra prize categories demanded "winning" some contest, to get better grades, and so on.

Deepening our analysis, in view of the work of Dicheva et al. [8], all the activities have a specific and clear goal, with clear, concrete, and actionable learning tasks. Feedback (and the associated badges) was given to the students right after the activity completion, and some of the activities demanded cooperation and/or competition between them. Even not having - by choice - a leaderboard, as the badges were delivered in class, the "gamified" students achieved reputation and recognition. Considering the freedom to fail principle, despite the fact that most of the activities could be delivered once, we think we followed this principle when the students could replace one regular badge (considered for

winning the final bonus) for one of the badges from the extra prize set.

5.4 Pedagogical Implications

The results presented by Deci et al. [3] indicate that it is more important to focus on more interesting learning activities to facilitate intrinsic motivation than to focus on rewards. We highlight that even with a gamified classroom, using the proposed badges, we tried to provide more interesting and challenging associated activities. We believe that, by doing so, we can balance the possible negative effects that rewards can exert on students' intrinsic motivation. However, we understand that this point (rewarded but challenging activities) needs to be deepened and explored in future research.

5.5 Threats to Validity

We presented a descriptive investigation. Not focusing on relational or experimental research, we were not able to identify relations between the observed facts or their causes.

As for the conducted study specifically, maybe the final bonus affecting the exam grades could have influenced some of the students' participation: they participated only to receive the points (affecting intrinsic motivation) or stopped participating after receiving 80% of the badges.

The possibility to earn more than one badge in the same activity (as the extra prizes) and be able to change it for another badge may have masked the result of some students.

6 FINAL CONSIDERATIONS

Gamification is an approach that has been used to motivate and engage students. Considering our main research question - **How does the use of badges in an HCI course contribute to student engagement?** -, our results show that badges contribute to student engagement mainly by providing an extra incentive for their participation. For instance, activities set to be done at home had a higher completion rate with the use of associated badges when compared to the completion rates from previous semesters. Before the adoption of the badges, home tasks were hardly ever engaged with by students. The results also point out the students' satisfaction with the gamified activities; in addition to being present in the students' testimonies, we were able to observe it empirically. We still have little evidence on the effect of badges on student grades; the data we already have, however, indicate that badges can indeed contribute to student engagement.

Considering the general scenario of research in this field, although we find several related studies, Hamari et al. [11] highlighted some limitations on this matter, such as small sample sizes in some studies, multiple affordances (points, leaderboards, badges, and so on) investigated as a whole, and short investigated timeframes. Moreover, Dicheva et al. [8] emphasize that more substantial empirical research is needed to inform who is interested in gamifying their courses, helping them to decide which game elements to use.

We move in this direction, believing our steps could assist pondering over gamification in HCI courses and also that our results could contribute to research about gamification in education in general. As for the limitations pointed out by Hamari et al. [11], we presented a study made in a class with 46 students (not small, in view of our national standards), during a whole semester, considering a single element (badge), and trying to explore it from multiple perspectives.

If, on the one hand, we agreed with Dicheva et al. [8], when they talk about the need of more research, on the other hand we disagreed with them: they highlight that one of the major obstacles for applying game elements to education is the lack of proper technological support. Our badge system was based on paper badges (stickers) in a highly technological scenario (an HCI course in the computing field), and this form of delivering the badges was one of the greatest motivators for the students' participation. They suggested the use of paper badges and they "collected" them, sticking on their notebooks, computers, smartphone cases, and so on: "*It is like Pokemon*" said - happily - one of the students in class.

6.1 Lessons Learned

Considering the experience described here and the experience obtained from the period of remote lessons we live at this moment (the 2020 Covid19 pandemic), we can highlight some lessons we learned which can help others trying similar approaches.

The original idea was conceived to work with digital badges. The students – in the first experience, which is described here - suggested the use of physical badges (stickers) and we observed their true happiness with the collection of stickers. The set of badges was developed over the semester. Maybe if the students had been able to see the full collection of badges from the beginning, they would have been even more motivated (as they enjoy the "collection" aspect of the badges).

Regarding the number of badges in a set, we believe a set should not be too small, or the badges too easily acquired. Students must be involved in the process and stimulated to collect them. For instance, in the last semester in which we applied the gamified system with real stickers (second semester of 2019), the set was composed of a total of 18 badges. Each semester we design new strategies and activities [18][19][20], associating them with corresponding badges.

This year – 2020 -, classes have been conducted remotely for the most part (remote teaching started at the end of March). We were forced to transform the collectable stickers into digital badges and alter the way we classify them. We gathered all the badges in a big set. Each badge was converted into 0.1 points, and the points were attributed to the course assignments. We have created an online leaderboard (in a Google spreadsheet) where they can keep track of the badges they have earned (as they cannot collect - and "count"- them physically). The students' names are hidden in the leaderboard - only a part of their University ID number is visible as an identifier -, to preserve their identities.

Lastly, we believe the general idea can be used in any course, as long as its specificities are taken into consideration and the implementation is carefully planned. We defend the diversity of badges used, in addition to the use of the printed stickers to

represent them. We hope to return soon to our face-to-face classrooms and our “collectable stickers”.

6.2 Next Steps

For now, in addition to working on the continuation of our gamified approach, we are also presenting our experience to HCI professors from other institutions and to professors in other fields, to discuss future possibilities and deepen our thoughts on it. We hope that sharing our experience could bring more colleagues to try methodological alternatives and share their experiences, towards a living curriculum approach [2].

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