Relating Gaming Habits with Student Performance in a Gamified Learning Experience

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ABSTRACT
Gamified education is a novel concept, and early trials show its potential to engage students and improve their performance. However, little is known about how different students learn with gamification, and how their gaming habits influence their experience. In this paper we present a study where data regarding student performance and gaming preferences, from a gamified engineering course, was collected and analyzed. We performed cluster analysis to understand what different kinds of students could be observed in our gamified experience, and how their behavior could be correlated to their gaming characteristics. We identified four main student types: the Achievers, the Regular students, the Halfhearted students, and the Underachievers, all representing different strategies towards the course and with different gaming preferences. Here we will thoroughly describe each student type and address how different gaming preferences might have impacted the students' learning experience.

Author Keywords
Gamification; Education; Cluster Analysis; Student Performance; Gamer Profiles; BrainHex

ACM Classification Keywords
H.5.2. User Interfaces: Evaluation/methodology

INTRODUCTION

Gamification is a recent process that consists of using game design elements in non-game processes [9, 10], as a means to make them more fun and engaging [20, 24] and thus, encourage users to adopt specific behaviors. Gamification has been used for many different purposes, such as engaging users with marketing programs [25], helping in driving instruction [13], promoting fitness and health awareness [7], improving one's productivity [23], and encouraging eco-friendly driving [15].

Introducing and training new skills has been one of the major uses of gamification. For example, Jigsaw [12] teaches Photoshop by using a jigsaw puzzle to challenge players to match a target image, and users stated they were able to explore the application and discover new techniques with this gamified approach. GamiCAD [16] is a tutorial system for AutoCAD that encourages users to perform line and trimming operations, to help NASA build a spacecraft. Users reported to have completed tasks faster and found the experience to be both more engaging and enjoyable with the gamified version of the tutorial. Prominent services that have adopted a similar approach are Microsoft Ribbon Hero[1] and Adobe Level Up[2], which rely on game elements like points, challenges and badges to get users to explore Microsoft Office and Adobe Photoshop respectively.

Given the great pedagogical possibilities games potentiate [14], gamification has been explored as a means to improve learning. In his book, Lee Sheldon [22] explains how a conventional course can be turned into a game, without using technology, where students start with an F grade and go all the way up to an A+, by completing challenges and gaining experience points. On another study, Domínguez et al. [11] compare two methods of taking optional exercises on an ICT course, where one consisted of consulting PDF files and the other of using a gamified system. In the latter, students were awarded with badges and medals on completion. Results show that students that used the gamified approach had better exam grades and reported deeper engagement with the course. Well-known online learning services like Khan Academy[3] and Codeacademy[4] teach students by providing them with video lessons and exercises to complete, while student progress is tracked using visual elements like points and badges.

Previously we have presented a long-term experiment in which we gamified a college course named Multimedia Content Production (MCP) [2]. Here, course activities were encapsulated into achievements and meaningful challenges, and game design elements like experience points, levels, badges and a leaderboard were added. We thoroughly

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[1] http://www.ribbonhero.com/ (visited April 5th 2014)
[2] http://adobe.ly/19dBNh1 (visited April 5th 2014)
[3] www.khanacademy.org (visited April 5th 2014)
[4] www.codecademy.com (visited April 5th 2014)

compared data regarding student performance and online participation, between gamified years and also between gamified and non-gamified years. Results show that students were more proactive and participative in the gamified version of the course, and that they found our course to be more motivating and interesting than other non-regular courses. However, we still know very little about how different types of students experience the course, and previous research work in this matter is scarce.

In this paper we present a new study where we analyzed how students performed over the term, and used clustering algorithms to identify what different types of strategies were adopted by students. Four types of students were identified, the Achievers, the Regular students, the Halfhearted students and the Underachievers, each representing different approaches towards our gamified course. In order to understand how their gaming preferences influenced the whole experience, we have also collected quantitative and qualitative data regarding their gaming habits, as well as their player profile according to the BrainHex model [18], which is based on neurological research related to gameplay. Here we will present a detailed description of each student type and correlate them with the students' gaming profiles.

GAMER PROFILING

A lot of groundwork has been established regarding player profiling, because the better we understand what different types of players like, the better we can tailor gaming experiences directed to them. One of the earliest and most well-known works is that of Richard Bartle [3, 4], were he identified what different types of MUD (multi-user dungeon) users enjoyed the most. Players could be classified according to their gaming preferences within a two axes system, each of which with two mutually exclusive forms: Acting – Interacting and Players – World. Four player types were thus considered: Socializers, who prefer to interact with other players (Interacting, Players); Killers, players that enjoy imposing and causing distress upon others (Acting, Players); Achievers, who assign themselves game goals and set out to achieve them (Acting, World); and Explorers, players that try to explore and find out as much about the world as possible (Interacting, World). A quiz consisting of a series of 30 questions was later created, which produces a score that classifies players into categories, based on their preferences. One of the main limitations of this model was that players could only have a single type at the same time.

Other classification models were later developed, such as the Demographic Game Design 1 (DGD1), proposed by Chris Bateman [5], which was primarily based on the Myers-Biggs personality model [17]. This model had the advantage of allowing players to be classified with combined playing styles, in opposition to the Bartle types. A subsequent model was developed, named BrainHex [18], which was based upon neurobiological responses inherent to playing games [6]. This model comprises seven player archetypes, each characterizing a specific playing style:

1. Seeker: typically "curious about the game world and enjoys moments of wonder". They usually prefer games where they can explore and find "strange and wonderful things".
2. Survivor: enjoys experiencing terror, which has normally a negative appraisal. They like to escape from "hideous and scary threads", and take "pulse-pounding risks".
3. Daredevil: this play style is all about the rush, taking risks and playing on the edge. They enjoy "dizzying platforms" and "rushing around at high speed".
4. Mastermind: these players "enjoy solving puzzles and devising strategies, as well as focusing on making the most efficient decisions."
5. Conqueror: these players are very challenge-oriented and they "enjoy defeating impossibly difficult foes, struggling until they achieve victory, and beating others."
6. Socializer: players fitting this archetype usually enjoy talking to other players, helping them and hanging around with people they trust.
7. Achiever: these players are more goal-oriented, and are motivated by long-term game achievements, like collecting special objects and amassing currency.

This model allows players to have both a main and a secondary class, and it comprises a list of oppositions to each style of play. We chose the BrainHex model to classify our students regarding their gameplay style because it is one of the most complete works in the field and it draws on the results of previous works, like the DGD1 and DGD2. Furthermore, an online questionnaire for this model is available, which makes it of easy access and easy administration.

THE MCP GAME

Multimedia Content Production is an MSc engineering gamified course in Information Systems and Computer Engineering, at Instituto Superior Técnico, University of Lisbon. The course follows a blended learning program, where students attend theoretical lectures and lab classes, but also get involved in discussions and complete assignments online using the Moodle[5] platform. Theoretical lectures cover multimedia concepts such as capture, editing and production techniques, multimedia standards, copyright and Digital Rights Management. In lab classes, varied concepts and tools are taught on image, audio and video manipulation, and there are regular assignments.

[5] www.moodle.org (visited April 5th 2014)

Figure 1. AvatarWorld.

Instead of receiving traditional grades, students participate in a game-like experience, where they had to accumulate experience points (XP) by completing course activities, which included a multimedia presentation (20% of total course XP), lab classes (15%), a final exam (30%), Skill Tree participation (10%), and a set of collectible achievements (30% plus a 5% extra). These required students to perform specific tasks, which would earn them XP and badges. Examples of these are attending lectures, finding resources related to class subjects, finding bugs in class materials, or completing challenges. Five percent of extra grade were distributed by several achievements so that students could achieve the 100% through different paths.

Achievements could either be single-level or multi-level, depending on how many iterations they required. Each iteration earned students XP and a badge. Although most achievements did not have a time limit to be accomplished, some involved the completion of time limited tasks. For example, Theoretical and the Lab Challenges required students to do creative works related to subjects taught on theoretical lectures and lab classes within periods of one to two weeks. There was also the MCP Quest, which was an online-riddle (similar to of Notpron[6]) where students started from a webpage with some sort of multimedia content, which they had to edit and manipulate to find the URL for the next clue of the riddle (or next level). The amount of awarded XP was proportional to the level of quest. In order to encourage every student to participate, they were required to contribute once in order to be awarded the XP, but a student could not post twice in a row. The MCP Quest and the Challenges were posted to course fora by faculty, and students had to post their responses accordingly. In order to allow students to do more of what they like, they were allowed to post up to three times in the same challenge, to make up for lack of participation in other less appealing challenges. Posts were evaluated by the faculty staff with a rating from 0 to 4, which was then translated to a specific amount of XP.

[6] http://notpron.org/notpron/ (last visited: April 18th, 2014)

Figure 2. The MCP leaderboard.

We also had an innovative game element, called AvatarWorld [1]. It was a 2.5D virtual world that evolves and grows as students are awarded with XP, with new buildings and characters being added. Students are represented by an avatar that can be used to explore the world. Its equipment can be customized with clothing and handheld objects, which students can unlock by acquiring certain course badges. Students can also create custom content for the game, like buildings and equipment, using tools and techniques taught in class. These were very specific tasks, which usually required more effort than most of the challenges and the quest. Submissions were also made via posts and were then graded by faculty, based on their creativity and technical correctness, and 600XP could be earned from it. In previous editions of the course, students requested more opportunities to be creative and autonomous in the course. Thus, AvatarWorld was introduced in this year, in an effort to improve both learning and gaming experience.

The Skill Tree is a game element that consists of a precedence tree where each node represented a thematic task, which would earn students XP upon completion. There were 6 base nodes that were already unlocked at the beginning of the course, and subsequent nodes could be unlocked when two preceding ones were completed. Students could gain a fair amount of XP from the Skill Tree, and this could be achieved by different paths. Each branch of the tree represented a theme, and students could either go all the way up to a top level node or just complete more base ones, according to their liking. Just like AvatarWorld, Skill Tree tasks were very specific and more demanding than most of the challenges or the MCP quest.

Students began the game with 0 XP and were awarded with more XP for undertaking course activities, which provided students with instant gratification. This was previously shown to be successful in motivating college students [19]. For each 1000 XP students increased in experience levels, and each level was labeled with a unique honorary title. Students had to reach level 10 in order to pass the course, and Levels max out at 20 (20000 XP), to match the traditional 20-point grading system used in our university.

The leaderboard was the main entry point to the gamified experience, allowing students to perform comparisons with others (see Figure 2). It was publically accessible from the forums, displaying students' scores sorted in descending order by level and XP. Each row showed the player's rank, photo and name, campus, XP, level and achievements completed. The leaderboard allowed students to assess both their progress and their peers'. By clicking on a student's row, the achievements and achievement history for that player were displayed. This turned game progression into a transparent process, by showing what had already been accomplished and what was yet to complete. Furthermore, it also transmitted valuable feedback that allowed students to learn by watching others.

STUDENT PROFILE ANALYSIS

Our previous study shows that students consider our course to be more motivating and interesting than other "regular" courses. Moreover, a comparison of several performance measures between gamified and non-gamified years shows that students are more proactive and participative on the gamified version of the course [2]. However, we do not yet fully understand how different types of students might experience our course, and neither do we know how they feel about games and what their gaming habits are. To better understand the nature of our students, we performed a new study where data regarding their performance and gaming preferences were collected and analyzed using cluster analysis.

In order to categorize students into different types, we had to identify a single measure of progress in the gamified experience, adequate to plot over time and use with a clustering algorithm. We initially considered both accumulated XP and rank over time as viable measures, but rejected the latter because students with equal performance could never be at the same rank. By plotting accumulated XP over time for every student, a few patterns became apparent, which seem to support the existence of different student categories. We then proceeded to cluster analysis, by using accumulated XP per day as attributes, to group students by similarities of XP acquisition. Expectation-Maximization (EM) [8] was the selected clustering algorithm, given that our sample was small and the number of clusters was not known beforehand [21]. The course lasted for 156 days and we had 54 enrolled students.

Usually, during the first days, most students have zero XP, either because they are not fully enrolled in the course or because there was still no significant activity. This makes all students' activity to look alike, which might mislead the clustering algorithm to group all students into the same cluster. To avoid this, we excluded from the analysis the first days that satisfied one of the following criteria: 1) there were still students whose enrollment process was not completed and were not playing the game yet, and 2) students were tied up at zero score due to lack of initial activity. As a result of this filtering process, 17 days were excluded from the study. This large number resulted mainly from significant lack of activity during the first two weeks, given that the professors were attending a conference during the first week, and not all students were enrolled yet in the second week. This limited student participation during the first days.

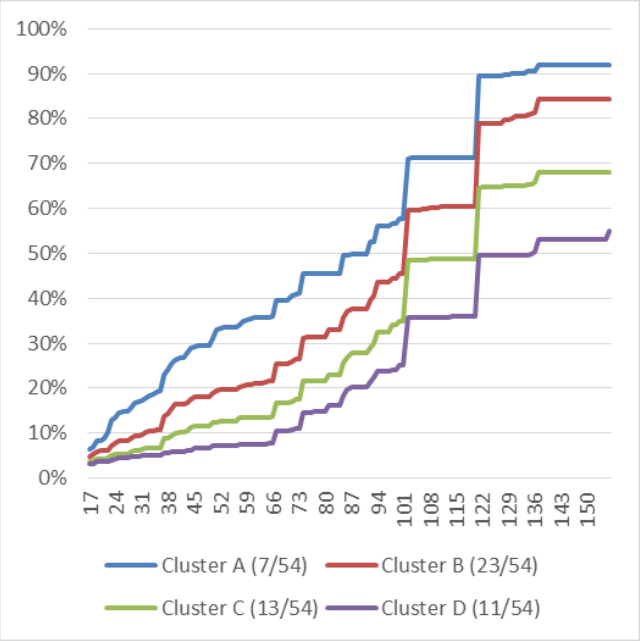

Figure 3. Average accumulated XP per day.

Four clusters were identified (from A to D), each portraying different XP acquisition patterns. In this section we will describe each one of them, taking into account student performance and participation measures. We also asked students to answer the BrainHex questionnaire and self-report the resulting classes in a questionnaire of our own, which also included additional questions regarding videogame playing habits. These will also be here addressed. Given that normality could not be assumed due the clusters' small size, we checked for differences between them using a Kruskal-Wallis test, with post hoc Mann-Whitney's U tests and Bonferroni correction. Questionnaire data was compared based on the responses' mode and respective percentage of students.

Cluster A

The first identified cluster was composed by 7 students, and it was characterized by a steep XP accumulation curve, which suggests these students were most of the time ahead of the others, as see in Figure 3. Here, every slope represents a significant XP acquisition, and these students appear to have grabbed every XP they could. This had a direct manifestation over their average ranking over the semester, with the top positions being mostly occupied by these students (see Figure 4). These students usually had the highest lab and final grade, made the most posts (both initial posts and replies), made the most rated posts and had

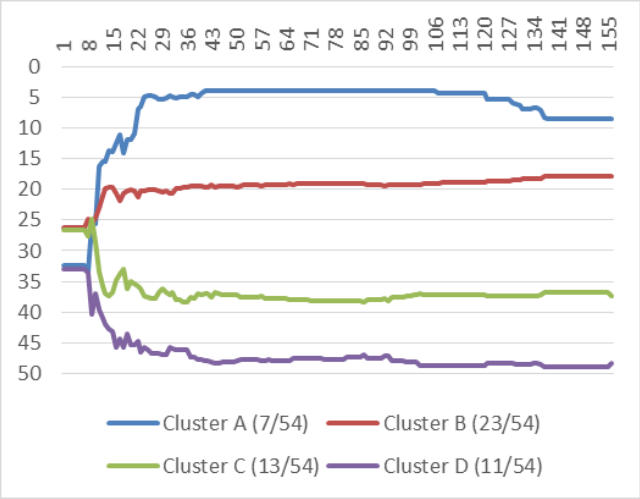

Figure 4. Average ranking per day.

the highest mean average rating per post, and earned the most XP from every game component (i.e. Challenges, MCP Quest, Skill Tree, AvatarWorld, and the Achievements) (see Figure 5).

All students from cluster A replied to the player characterization questionnaire, where 71% of the students were male. A majority of them (57%) affirmed they played videogames every day, and 43% of them considered they were something between a hardcore and a casual gamer. All of cluster A students stated they preferred multiplayer games over single player games, and 86% stated that computer is the device they usually play the most with. All students from this cluster considered they usually played in a personal computer, 71% in videogame consoles, and 86% said that they did not usually play with portable videogame consoles, tablets or smartphones. The most played type of videogame by this cluster was Role Playing Game (RPG), and the most common BrainHex classes were Mastermind and Socializer (29% of the students, each) for the main class, and Conqueror (71%) for the secondary class.

Cluster B

Cluster B, the largest one with 23 students, was characterized by a less steep XP accumulation curve than that of cluster A. These students had slightly above average XP accumulation levels, which put them right below cluster A students in the leaderboard. They had the highest mean multimedia presentation grade and exam grade, made the second most posts, and had the second highest mean average rating per rated post. These students performed close to cluster A students on most game components, with the exception of the Skill Tree and AvatarWorld, where they fell behind.

All cluster B students replied to the player characterization questionnaire, but one claimed to never play games. Consequently, this student's data was excluded. A large portion of them (61%) was male, and 39% stated they

Property	A	B	C	D	All	Significant Differences (p < 0.05)
Labs Grade (%)	96.24	94.28	89.23	73.36	89.06	(B, D)
Presentation Grade (%)	78.50	83.33	82.23	64.18	78.54	None
Exam Grade (%)	63.67	65.50	56.02	55.67	60.98	(B, C)
Final Grade (%)	91.79	84.28	68.09	54.94	75.38	(A, C), (A, D), (B, C), (B, D), (C, D)
Attendance (%)	82.31	87.78	50.55	33.77	67.11	(A, D), (B, C), (B, D)
Posts (#)	76.71	48.09	21.77	10.55	37.81	(A, B),(A, C), (A, D), (B, C), (B, D)
First Posts (#)	3.86	2.39	0.46	0.55	1.74	(A, C), (A, D), (B, C)
Reply Posts (#)	72.86	45.70	21.31	10.00	36.07	(A, B),(A, C), (A, D), (B, C), (B, D)
Rated Posts (#)	44.57	28.22	14.08	7.55	22.72	(A, B),(A, C), (A, D), (B, C), (B, D)
Mean Rate	3.46	3.35	3.33	3.01	3.29	None
Challenge Posts (#)	16.86	16.26	9.69	5.27	12.52	(A, C), (A, D), (B, C), (B, D)
XP from Challenges (%)	100.00	95.65	71.79	40.26	79.19	(A, C), (A, D), (B, C), (B, D)
Theoretical Challenge Posts (#)	8.71	8.65	5.54	2.82	6.72	(A, D), (B, C), (B, D)
XP from Theoretical Challenges (%)	100.00	95.65	71.79	36.36	78.40	(A, D), (B, C), (B, D)
Lab Challenge Posts (#)	8.14	7.61	4.15	2.45	5.80	(A, C), (A, D), (B, C), (B, D)
XP from Lab Challenges (%)	100.00	95.65	71.79	45.45	80.25	(A, D), (B, C), (B, D)
Skill Tree Posts (#)	20.86	12.43	4.62	3.18	9.76	(A, B),(A, C), (A, D), (B, C), (B, D)
XP from Skill Tree (%)	100.00	64.57	20.77	17.95	49.12	(A, B),(A, C), (A, D), (B, C), (B, D)
Explored Skill Tree Nodes (#)	11.71	7.91	2.69	2.27	6.00	(A, B),(A, C), (A, D), (B, C), (B, D)
MCP Quest Posts (#)	2.29	2.30	1.31	0.18	1.63	(A, D), (B, D)
XP from MCP Quest (%)	100.00	95.65	69.23	18.18	74.07	(A, D), (B, D)
AvatarWorld Posts (#)	17.57	5.17	3.62	0.09	5.37	(A, B),(A, C), (A, D), (B, D)
XP from AvatarWorld (%)	97.62	25.36	10.26	1.52	26.23	(A, B),(A, C), (A, D)
AW Submissions (#)	21.86	6.261	2.462	0.182	1.593	(A, B),(A, C), (A, D)
Badges (#)	50.43	40.70	28.77	20.09	34.89	All
XP from Achievements (%)	100.00	93.88	69.97	44.36	78.83	(A, C), (A, D), (B, C), (B, D), (C, D)
Completed Achievements (#)	14.57	11.52	6.92	4.55	9.39	All
Explored Achievements (#)	22.71	18.91	15.69	11.09	17.04	All

Figure 5. Student performance metrics per cluster.

played videogames every week. Furthermore, 52% of them considered they were casual gamers, 57% showed preference for multiplayer games over single player ones, and 70% said the personal computer was the device they played the most with. All cluster B students confirmed they usually played in a personal computer, whereas videogame consoles and smartphones were also usually played by 57% of them. However, 83% and 78% considered they did not usually play with portable video game consoles and tablets respectively. The most played type of game by cluster B was Real-time Strategy (RTS), and the most common BrainHex classes were Achiever and Mastermind (26% of the students, each) for the main class, and Conqueror (39%) for the secondary class.

Cluster C

Cluster C was composed by 13 students, and they typically presented a sub average XP accumulation curve and an average ranking lower than that of Cluster B. These students typically had grades below those of clusters A and

B, with the exception of the multimedia presentation and the exam grades, which were the second highest. Cluster C students made the third most posts but had the lowest number of first posts, even though this difference was not significant in comparison to any of the other clusters. They also made the third most rated posts and had the third highest mean average rating per post. These students contributed poorly to the Skill Tree and AvatarWorld, and had below average participation in the other game components.

Regarding the player characterization questionnaire, we had responses from all but one student on this cluster. Of these students, 92% were male, and 58% stated that they play videogames every day. Also, 42% considered themselves something between a hardcore and a casual gamer, 83% preferred multiplayer games over single player, and 67% affirmed that the personal computer was the device they played the most with. All students from this cluster affirmed they usually played videogames on a personal computer, 58% on videogame consoles and 50% on smartphones, but 83% considered that they usually did not play on a tablets and 75% on portable videogame consoles. The most played game type by these students was Shooter, but RPGs were also predominant. A majority of the students (67%) had the Conqueror as their main BrainHex class, and 42% had Mastermind as the secondary one.

Cluster D

The fourth cluster was composed by 11 students, and it was characterized by a rather low and less steep XP accumulation curve, as compared to any other cluster, which pushed them to the bottom positions of the leaderboard. Students from this cluster had the lowest grades on all evaluation components, posted the least, and had the lowest average rating per rated post. They ignored the Skill Tree, AvatarWorld, and the MCP Quest, and performed below average on the Challenges.

All students from this cluster replied to the player characterization questionnaire, where all were male, and 55% affirmed they played games every day. Furthermore, 45% considered to be something between hardcore and casual gamers, 64% preferred single player games over multiplayer, and all of them confirmed that the personal computer where the device they played the most with. All students stated they usually played with the computer and 55% also with videogame consoles. Yet, 91% considered they usually did not play with portable videogame consoles, 82% with tablets, 73% with smartphones. The most played type of game played by these students were RPGs. The most common BrainHex classes were the Conqueror for the main class (36%) and the Conqueror, the Daredevil and the Mastermind (27% each) for the secondary class.

DISCUSSION

By analyzing student data from our experiment we identified different student profiles, each with different gaming habits and different approaches towards our course. In order to improve the knowledge about our students, and be able to better shape our learning experience according to their needs, we will answer two research questions: 1) what characterizes the four clusters and how do they compare to each other, and 2) how do their gaming habits relate to their performance and preferences in the course.

Student Characterization

Cluster A was the smallest, and it was composed by students that did all they could to get XP – they wanted to collect every single achievement in the game. This was the only cluster acquiring 100% of all grade reserved for challenges, the Skill Tree, the MCP Quest, and all achievements. They also scored almost the maximum grade on AvatarWorld, had the best lab grade, and were the most proactive and participative in terms of posts. They made the most rated posts in an effort to get as much XP as they could get, which is reflected by their rating/#posts ratio, which is the lowest (0.078). As a result, these students had the highest mean final grade. Because these students went after every achievement and XP they could get, we named them the *Achievers*. These students seem to have benefited the most from the gamified components of the course.

Cluster B was the largest cluster, which included almost 43% of the students. These students' lab grade was almost as high as that of the Achievers, and they had the highest multimedia presentation grade and exam grade. Their performance on game components like the challenges, the MCP Quest, and achievements, was really close to that of the Achievers, but they worked significantly less for AvatarWorld and the Skill Tree. While they still managed to grab almost 65% of the total grade allocated to the Skill Tree, they only got 25% of that reserved for AvatarWorld. They were also significantly less participative than the Achievers, but yet managed to perform the second highest number of rated posts, in order to squeeze some additional XP. Thus, their rating/#posts ratio was the second lowest (0.119). Cluster B students represented the largest number of students in our course, which were characterized by high participation levels on almost every component, with the exception of AvatarWorld and the Skill Tree, and also high performance levels, slightly lower than those of cluster A. These students often ended the course with above average final grade (with the average being 75.38%). Because of these features, we named these the *Regular students*.

Cluster C was the second largest cluster, and it consisted of students that had poorer performance than the aforementioned two clusters, in every aspect except for the multimedia presentation, where they scored the second highest grade. These students still managed to grab around 70% of the grade allocated to challenges and to the MCP Quest, but their participation on the Skill Tree and AvatarWorld was rather low, which earned them respectively around 20% and 10% of the allocated grade. Cluster C students had the lowest number of first posts and

the second lowest number of reply posts, which rendered them the cluster with the lowest proactivity levels. However, they still performed slightly more rated posts than cluster D and managed to get a mean post rating almost as high as that of the Regular students, which granted them with the second highest rating/#posts ratio (0.237). These students typically ended the course in a slightly below average final grade. Even though these students went after the XP available on challenges and the MCP Quest, they seemed generally uninterested by most of the other components. Because of this, we named them the *Halfhearted students*.

Cluster D was composed by the students with the poorest performance. They had the lowest grades on the exam, the lab classes, the multimedia presentation, and also on the challenges, the MCP Quest, the Skill Tree and the AvatarWorld. These students seem to have ignored most of the game components of the game, having scored only 44% of the XP allocated for the achievements. They had the lowest mean final grade (55.67%), slightly above the minimum required to pass the course (50%). These students also had the lowest participation values, even though they were similar to cluster C in terms of first posts. They also performed the fewest rated posts, but really made them count, with an average rating of 3. Thus, they presented the highest rating/#posts ratio (0.397). Given their low performance we named these students the *Underachievers*.

Our data suggests that our students are structured into four tiers, each representing four distinct levels of performance. Halfhearted students and Underachievers seem to be easily identifiable in comparison with each other and with the Achievers and the Regular students, as they present very distinct levels of final grade and grade earned from achievements. This is easily observable by taking a look at their final ranking at the end of the course (see Figure 6), where they seem to occupy distinct areas of the bottom half of the leaderboard. However, it is harder to tell the Achievers and the Regular students apart, as they equally shared the top 1/3 of the leaderboard. The differences in terms of final grade and grade earned from achievements are not significant; what changes is how they achieved those grades.

Achievers put a lot of effort in every game component of the course, acquiring 100% of the XP allocated to them, but they were also the best on the lab classes. On the other hand, Regular students performed close to the Achievers on most achievements and game components, with the exception of the Skill Tree and AvatarWorld, but were still able to make up for it by having the best scores on the multimedia presentation and the exam. This allowed both student types to share the same position of the leaderboard, because they accumulated similar levels of XP through different paths.

Distinguishing the Halfhearted students and the Underachievers is easier, as both presented a gradual loss of

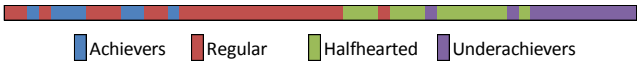

Figure 6. Final student ranking, with the first position on the far left.

performance in almost all evaluation components. However, the Halfhearted students tried to grab XP from both the challenges and the MCP Quest, which were usually easier to attain than participating on the Skill Tree and AvatarWorld. Consequently, these two components were mostly ignored. On the other hand, Underachievers seem to have ignored most of the game aspect of the course and focused solely on getting just enough XP to pass.

Student Gamer Profiling

Most student types preferred multiplayer over single player games. The exception were the Underachievers, whose majority preferred single player games. Coincidently, these students also had the worst performance, but further statistical analysis must be carried out to understand any effect of this factor over student performance.

Most students considered themselves to be something between a hardcore and a casual gamer, which we considered normal was it was a middle ground between both. Still, Regular students had the largest incidence of students considering themselves as casual gamers, and they also affirmed that they played weekly rather than daily, as compared to the other student types. Coincidently, this was also the cluster with the largest female population, which suggests that the greater incidence of female students might have rendered this cluster as playing less frequently. We found a weak correlation between gender and being an hardcore gamer or not (Cramer's V coefficient, $\varphi_c = 0.324$), and between gender and frequency of play ($\varphi_c = 0.288$), which weakly suggests that female students might have considered themselves as being more casual gamers than male students and as playing less too. Interestingly, we also found significant differences in terms of grades between genders (Mann Whitney's U test, $p < 0.02$), with girls having an average grade of 85.03% as compared to the boys' 72.72%.

Most students played the most with the computer, but video game consoles were also very predominant. The Achievers typically preferred to play RPGs the most and their predominant main class were the Socializer and the Mastermind. While Socializers usually prefer multiplayer experiences where they can hangout and collaborate with people, Mastermind players typically enjoy strategic play. We deem our experience has being potentially more appealing for these two types of BrainHex players, given that the inherent experience is collective and that different strategies can be employed to achieve the top grade, by exploring different paths and thr rule system.

Regular students typically preferred RTS games and their main BrainHex classes were the Achiever and the

Mastermind. Again, Mastermind players like to use strategy to overcome obstacles, and Achievers like to complete tasks and collections. We believe that our experience might also have been very appealing to this type of students, given the wide variety of achievements, Skill Tree nodes and challenges to explore and complete.

Both the Halfhearted students and the Underachievers presented a similar configuration regarding their BrainHex classification, with the main class being the Conqueror. Conqueror players usually enjoy defeating difficulty foes and beating other players. We believe that our gamified experience was not appealing to this type of player, given that there was never a concrete opponent to defeat and to struggle against. This might have been an additional factor contributing to the reduced engagement of these two student types, which might have contributed to their reduced performance.

Study Limitations

This study has a few limitations, mostly related to the small size of our sample, which caused one of the clusters to have as few as 7 students. This makes it hard to drawn any major conclusions from this study. However, it is still an important and valuable contribution to help us better understanding how different students experience gamified learning and how their gaming habits may potentially influence their behavior.

CONCLUSIONS AND FUTURE WORK

In a previous experiment we had gamified an engineering MSc course, where course tasks were encapsulated into meaningful challenges and game elements like experience points, levels, badges, and a leaderboard were added. A thorough study showed that students participated more and could perform better with our course, and that they also considered it more motivating and interesting than other non-gamified courses.

In this paper we presented a new study where we collected and analyzed data regarding the students' performance in the course and also regarding their gaming habits and preferences, in order to find how different types of students experienced our new learning method. We performed cluster analysis in our data and four types of students became apparent: the Achievers, who strived to collect every achievement in the game; the Regular students, who had good overall performance but avoided some of the more demanding game components; the Halfhearted students, whose interest by the course was limited and usually performed below average on most aspects; and the Underachievers, who performed the worst and did just enough to pass the course. These students were also characterized by distinct gaming habits. For instance, Regular students seem to play less often than other student types, and also seem to be predominantly classified as Mastermind and Achievers, according to the BrainHex types. Our Achievers, on the other hand, were classified as the BrainHex's Socializer and Mastermind classes, while the Halfhearted students and the Underachievers were labeled as the Conqueror.

Not only did this study enrich our understanding about how different students might address gamified learning, and how their gaming preferences might relate to how they experience it, but it also laid valuable groundwork for future research. We would like to further explore more possible correlations between the BrainHex classes and what students enjoy doing in the course, and study how this could be used to make the system adapt to them. Furthermore, we would like to perform a more thorough statistical analysis to unveil potential correlations between student performance and their gaming preferences.

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