# Identifying Student Types in a Gamified Learning Experience

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## ABSTRACT

Gamification of education is a recent trend, and early experiments showed promising results. Students seem not only to perform better, but also to participate more and to feel more engaged with gamified learning. However, little is known regarding how different students are affected by gamification and how their learning experience may vary. In this paper we present a study in which we analyzed student data from a gamified college course and looked for distinct behavioral patterns. We clustered students according to their performance throughout the semester, and carried out a thorough analysis of each cluster, regarding many aspects of their learning experience. We clearly found three types of students, each with very distinctive strategies and approaches towards gamified learning: the Achievers, the Disheartened and the Underachievers. A careful analysis allowed us to extensively describe each student type and derive meaningful guidelines, to help carefully tailoring custom gamified experiences for them.

**Keywords**: Gamification, Education, Gamified Learning, Student Types, Cluster Analysis, Expectation-Maximization

### INTRODUCTION

Videogames are being widely explored to teach and convey knowledge (de Aguilera & Mendiz, 2003; Squire, 2003), given the notable educational benefits and pedagogical possibilities they enable (Bennett et al., 2008; O'Neil et al., 2005; Prensky, 2001). Research shows that video games have a great potential to improve one's learning experience and outcomes, with different studies reporting significant improvements in subject understanding, diligence and motivation on students at different academic levels (Coller & Shernoff, 2009; Kebritchi et al., 2008; Lee et al., 2004; Mcclean et al., 2001; Moreno, 2012; Squire et al., 2004). As found by Gee (Gee), good games are natural learning machines that, unlike traditional educational materials, deliver information on demand and within context. They are designed to be challenging enough so that players will not grow either bored of frustrated, thus allowing them to experience flow (Chen, 2007; Csikszentmihalyi, 1991).

Gamification is defined as using game elements in non-game processes (Deterding et al., 2011a; Deterding et al., 2011b), to make them more fun and engaging (Reeves & Read, 2009; Shneiderman, 2004). It has been used in many different domains, like marketing programs (Zichermann & Cunningham, 2011; Zichermann & Linder, 2010), fitness and health awareness (Brauner et al., 2013), productivity improvement (Sheth et al., 2011) and promotion of eco-friendly driving (Inbar et al., 2011). Gamification can also be used to help people acquire new skills. For example, Microsoft Ribbon Hero (www.ribbonhero.com) is an add-on that uses points, badges and levels to encourage people to explore Microsoft Office tools. Jigsaw (Dong et al., 2012) uses a jigsaw puzzle to challenge players to match a target image, in order to teach them Photoshop. Users reported Jigsaw allowed them to explore the application and discover new techniques. GamiCAD (Li et al., 2012) is a tutorial system for AutoCAD, allowing users to perform line and trimming operations to help NASA build an Apollo spacecraft. Results show that users completed tasks faster and found the experience to be both more engaging and enjoyable, as compared to the non-gamified system.

Gamifying education is also on the rise, even though empirical data to document major benefits are still scarce. In his book, Lee Sheldon (Sheldon) describes how a conventional course can be cast as an exciting game, without using technology, where students start with an F grade and go all the way up to an A+, by completing quests and challenges, and gaining experience points. Domínguez et al. (Domínguez) proposed a new approach to an e-learning ICT course, where students can take optional exercises, either via a PDF file or via a gamified system. In the latter, students were awarded with badges and medals by completing the exercises. Results show that students that opted for the gamified approach had better exam grades and reported higher engagement in the course. Well-known online learning services, like Khan Academy (www.khanacademy.org) and Codeacademy (www.codecademy.com), allow students to learn by reading and watching videos online, and then performing exercises. Student progress is usually tracked using visual elements, including energy points and badges. The didactical possibilities that gamification unveils are manifold, and their use in MOOCs to stimulate a participative culture have also been explored (Grünewald et al., 2013).

In a previous work we described a long-term study where a college course, Multimedia Content Production (MCP), was gamified (Barata et al., 2013). The experiment was held on two consecutive academic years, a non-gamified and a gamified one, to evaluate how gamification affected the students' learning experience. By carefully comparing empirical data garnered during both years, we observed significant improvements in terms of student participation, lecture attendance and amount of lecture slides downloads. Furthermore, students reported that they perceived the course as being more motivating and interesting than other "regular" courses. In this paper we describe a new study, where we analyzed the students' progression over time and identified three distinct student types, each of which seemingly experienced the gamified course differently. We will present a thorough analysis of each type, regarding many aspects of their learning experience, which reveal different strategies and levels of performance, diligence and engagement to the course. We will further discuss the lessons learned from this experiment and derive relevant design implications to future gamified learning experiences.

## THE GAMIFIED MCP COURSE

MCP is an annual semester-long MSc gamified course in Information Systems and Computer Engineering at Instituto Superior Técnico, the engineering school of the University of Lisbon. The course runs simultaneously on two campuses, Alameda and Taguspark, in a completely synchronized fashion, using a shared Moodle platform (www.moodle.org). The faculty included four teachers, two for each campus. We had 35 enrolled students (12 at Alameda and 23 at Taguspark), of which a large majority completed their undergraduate computer science degree on the previous year, and three were foreign exchange students (under the Erasmus Exchange Program). The syllabus included 18 theoretical classes, 12 lab classes and four invited lectures. The theoretical lectures covered multimedia concepts such as capture, editing and production techniques, file formats and multimedia standards, as well as Copyright and Digital Rights

Management. Laboratory classes explored concepts and tools on image, audio and video manipulation. Students had to develop plugins for the PCM Media Mixer, a multimedia editor built on DirectShow, as part of their lab assignments.

In our first experiment, we gamified the course in an attempt to make it more engaging, fun and interesting than the traditional format (Barata et al., 2013). The course was restructured to embody game elements, such as experience points (XP), levels, leaderboards, challenges and badges, which seem to be some of the most consensual elements employed in gamification

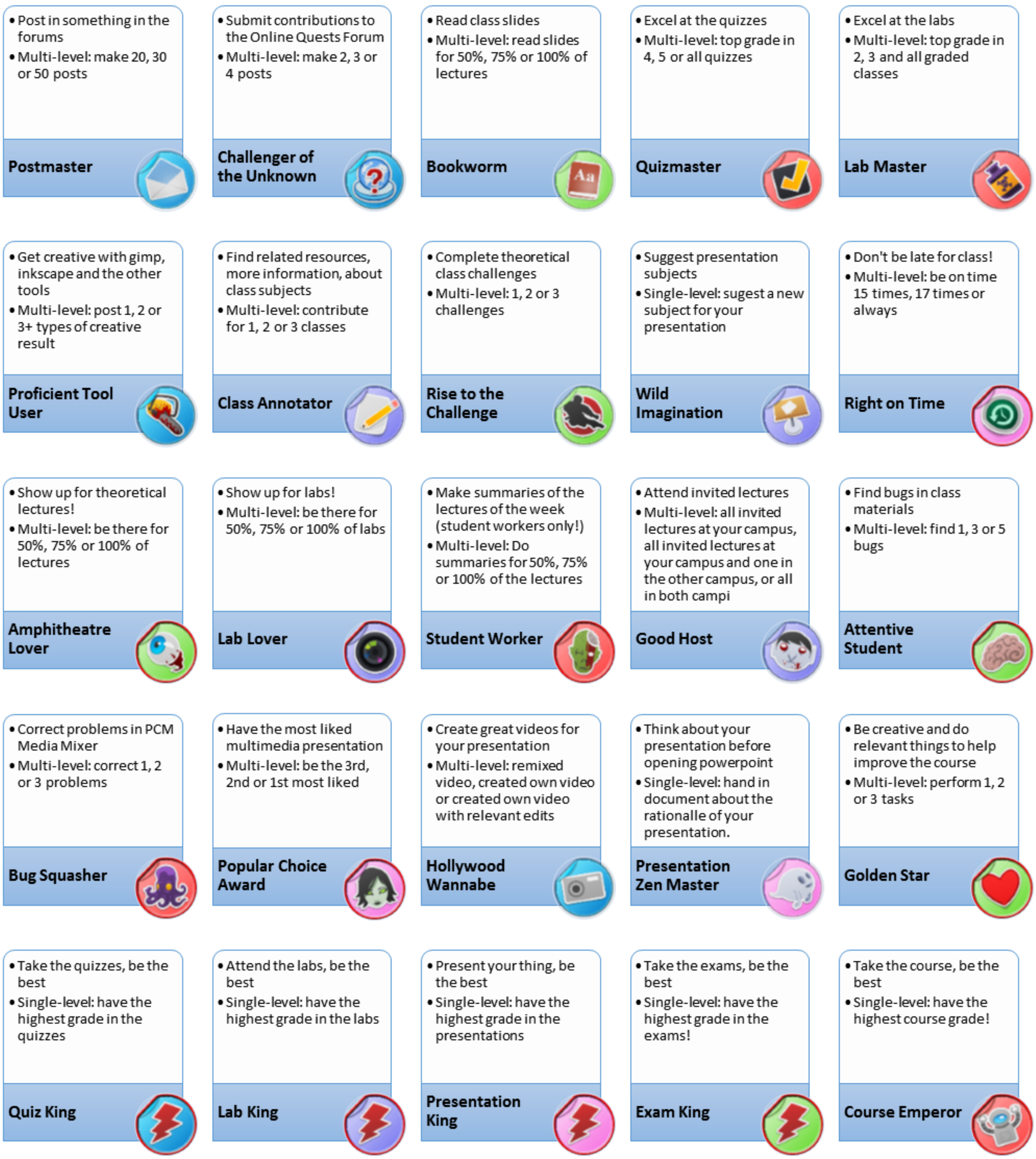


*Figure 1. List of all achievements in the MCP course.*

(Crumlish & Malone, 2009; Kim, 2008; Werbach & Hunter, 2012; Zichermann & Cunningham, 2011). These elements were used to turn course activities into more engaging endeavors. Thus, unlike a traditional course, students participated in a game-like experience and were awarded experience points (XP), instead of grade points, upon meeting evaluation criteria. Course activities comprised quizzes (20% of maximum XP), a multimedia presentation (20%), lab classes (15%), a final exam (35%) and a set of collectible achievements (10% plus 5% extra), awarded to students for completing assorted course tasks.

## Playing the Game

Most of the course's activity took place in our Moodle platform, where students were awarded XP for completing traditional activities (quizzes, multimedia presentation, lab classes and exam), but also for obtaining achievements (Barata et al., 2013). These required students to perform specific tasks, in order to earn XP and badges (see Figure 1). Examples of these include attending lectures, finding resources related to class subjects, finding bugs in class materials or completing challenges.

Achievements could either be single-level or multi-level, depending on how many iterations they required. Each iteration (or level) earned students XP and a badge. While most achievements did not have a time limit to be completed, there were a few that had specific deadlines. Examples were: "Rise to the Challenge", where students had to complete Theoretical Challenges related to subjects introduced in the lectures; "Proficient Tool User", which required students to use tools taught in lab classes creatively, in response to Lab Challenges; and the "Challenger of the Unknown", where students had to complete Online Quests, by posting relevant reference materials according to specific subjects. Challenges and Quests were posted to course fora by faculty, and students posted their responses accordingly.

Students began the game with 0 XP and were awarded with XP for undertaking course activities, to encourage them to learn from failure (Sheldon, 2011). XP also provided instant gratification, which was shown to be successful in motivating college students (Natvig et al., 2004). For each 900 XP students acquired experience levels, and each level was labeled with a unique honorary title. Students must reach level 10 in order to pass the course, and levels max out at 20 (18000 XP), to match the traditional 20-point grading system used in our university.

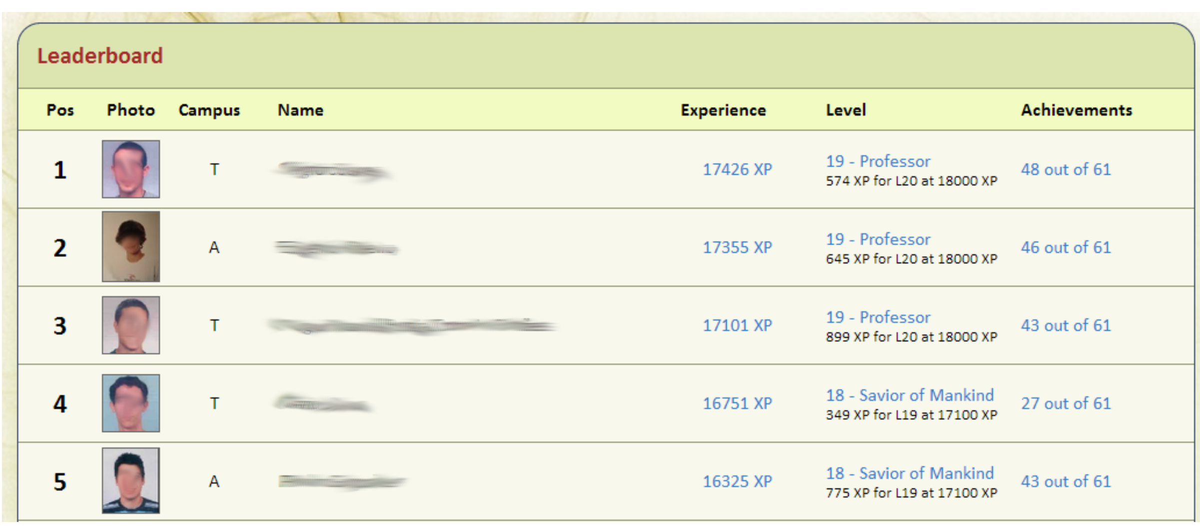


*Figure 2. The MCP leaderboard.*

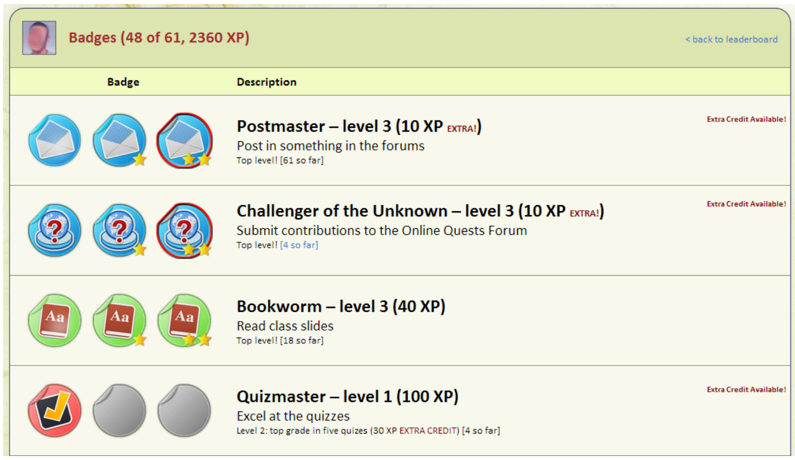


*Figure 3. Achievement history of a student.*

A leaderboard was the main entry point to the gamified experience, allowing students to compare themselves to others. It was publically accessible from the Moodle forum, displaying students' scores sorted in descending order by level and XP (see Figure 2). 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 (see **Error! Reference source not found.**). This turned game progression into a transparent process, by showing what had already been accomplished and what was yet to complete. Furthermore, this transmitted rich feedback to students, allowed them to learn by watching others, and guided them while spurring competition.

### Element Selection Rationale

Student performance seems to be tightly connected to how intrinsically motivated they are (Ryan & Deci, 2009). Indeed, Self-Determination Theory (SDT) identifies three innate needs of intrinsic motivation (Deci & Ryan, 2004): Autonomy, a sense of volition or willingness when performing a task; Competence, referring to a need for challenge and feelings of effectance; and Relatedness, experienced when a person feels connected to others. We tried to align the course's goals with those of students', to improve the experience's intrinsic value (Deterding, 2012). To that end, we used SDT as a basis to select game elements and integrate those in the course. We tried to improve the students' sense of autonomy by allowing them to choose what challenges and achievements to pursue towards leveling up. Additionally, we aimed at boosting their sense of competence by providing positive feedback and progress assessment through points, levels and badges. Last, we tried to promote relatedness by providing competition (via leaderboard), cooperation and online interaction among players (via Moodle).

### Gamification Impact

In a previous experiment we collected data over two consecutive years, the last non-gamified version of the course and the first gamified one (Barata et al., 2013). These data counted many aspects of the students' learning experience, including downloads of course materials, attended lectures, posts to course fora, final grades, as well as qualitative data garnered through a satisfaction questionnaire. These elements were then compared between years, and a thorough analysis showed significant improvement in terms of first and reply posts, the number of downloads of lecture slides, and the attendance of theoretical lectures. However, no significant changes were observed on student grades. Yet, questionnaire data showed that students deemed our course to be more motivating and interesting, as compared to regular courses. In short, we have indeed observed remarkable improvements in terms of both online participation and proactivity, and found evidence that students were more engaged with the course. However, informal observation of student behavior and progression over time suggests that different students may experience the gamified course in different ways. This motivated us to further explore our data and perform the study here reported, whose scope is to identify different categories of students and discuss how their experience can be improved.

## CLUSTER ANALYSIS

Informal observation of student behavior led us to believe that students could be differentiated by the way they progressed in the course, as if there were different types of players of the MCP game. To classify students into different categories, we had to identify a single measure of progress in the gamified experience, which would be capable of both being plotted over time and used in a clustering algorithm. We deemed both accumulated XP and rank over time to be viable candidates, but ended up rejecting rank since students with equal performance could never be at the same rank. By programmatically plotting accumulated XP over time for every student and analyzing it by eye, a few patterns became apparent, which seem to support the existence of different student categories. We used cluster analysis to find them.

We performed cluster analysis using Weka, a collection of machine learning algorithms for data mining tasks in Java (www.cs.waikato.ac.nz/ml/weka/). Several algorithms were available to perform the analysis, such as the well-known K-Means (MacQueen et al., 1967), which is one of the simplest unsupervised learning algorithms for clustering. However, it requires the number of cluster to be supplied as a parameter and since we did not know it beforehand, we had to exclude this algorithm as a viable candidate. COBWEB (Fisher, 1987) was another alternative, but it assumes that that probability distributions on separate attributes are statistically independent of one another, which might not true because correlation between attributes often exists (Sharma et al., 2012). DBSCAN (Ester et al., 1996), is a density-based algorithm that does not suffer from the previous problem, but it does not work well with high-dimensional data, such as ours (one dimension for each day). We selected the Expectation-

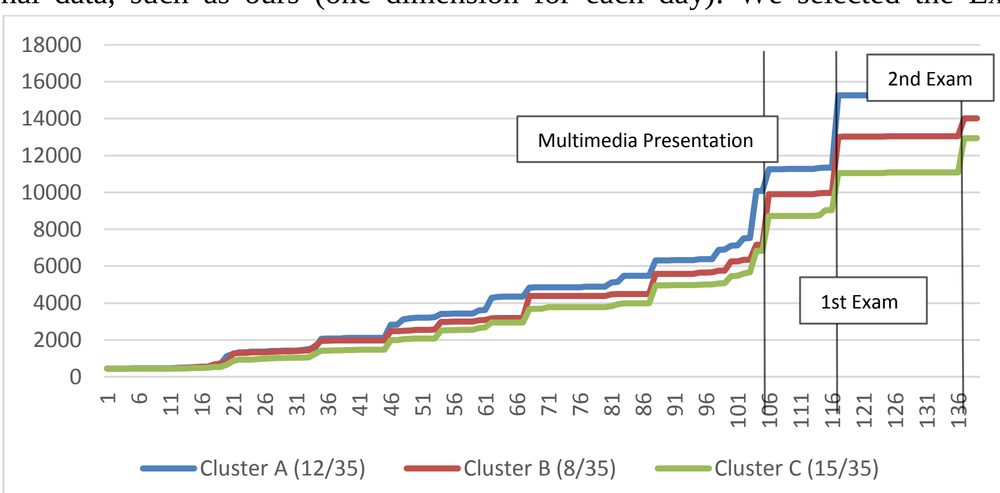


*Figure 4. Average student accumulated XP per day.*

Maximization (EM) algorithm (Dempster et al., 1977), given that is does not require the number of clusters to be specified beforehand and it works well with small datasets (Sharma et al., 2012). EM assigns a probability distribution to each instance that indicates the probability of it belonging to each of the clusters. The algorithm decides how many clusters will be created by cross validation. We used the default parameters: 100 as the maximum number of iterations, 1.0E-6 as the minimum standard deviation, 100 as the random number seed, and did not specify the number of cluster, allowing the algorithm to decide the ideal number of clusters for the data. As attributes were passed the amount of accumulated XP per each day, and students were assigned to the cluster with the higher probability, thus grouping them by similarity or dissimilarity of XP acquisition over time. The course lasted for 135 days, but the first four were excluded, given that there was no activity and all students were tied at zero score during that period.

Applying EM to our dataset yielded three clusters, each representing a distinct XP acquisition pattern. By looking at each clusters' average XP acquisition per day (see Figure 4), we can see that students belonging to cluster A were always ahead of others. Each slope represented an opportunity to get XP and at each slope we saw cluster A students taking advantage of it. Cluster B students presented a similar behavior to cluster A during the first six weeks. However, from then on, they seemingly failed to keep up the pace. Cluster C students were always at the bottom, consistently earning minimal XPs, just enough to pass the course.

To better understand these three student types, we analyzed each cluster and characterized them regarding the students' learning experience and performance, including data from a satisfaction questionnaire, answered at the end of the term. Given that the clusters are small and normality could not be assumed, we checked differences between clusters using a Kruskal–Wallis one-way analysis of variance with post-hoc Mann-Whitney's U tests and Bonferroni correction, to counteract the problem of multiple comparisons ($\alpha = 0.05/3 = 0.016$). Given the large information to present, we refer readers to Figure 5 for additional details on performance data.

## Cluster A

Cluster A was composed by 12 students. They had the best mean final grade and mean grade for every evaluation component, with the exception of quizzes, whose differences were only significant compared to cluster C. They also presented the highest theoretical lecture attendance and overall lecture attendance (which comprised theoretical and invited lectures), but these differences were only significant as compared to cluster C. As for online activity, cluster A students performed an average number of downloads of course material, but downloaded the most lecture slides. However, there were no significant differences regarding these measures across clusters. These students also had the highest number of posts on Moodle, but the difference was only significant as compared to cluster C. By breaking these numbers into first and reply posts, cluster A also performed better than others here, which denotes increased proactivity and participation, but significance was only observed for reply posts. Nonetheless, students from cluster A made more than twice the number of first posts per student, compared to other clusters.

Cluster A students were also the major contributors to both Challenges and Online Quests. They posted more on Challenge threads than the other clusters, with this number being almost twice that of cluster C, and this difference is significant. Consequently, they also received more XP from challenges and, again, this difference was only significant compared to cluster C. Considering that that there were two types of challenges, these students performed two times

| Property | Cluster A | Cluster B | Cluster C | All | Significant Differences (p < 0.016) |
|---|---|---|---|---|---|
| Quizzes Grade (%) | 82.22 | 77.50 | 66.00 | 74.19 | (A, C) |
| Labs Grade (%) | 95.96 | 85.45 | 81.32 | 87.28 | (A, B), (A, C) |
| Presentation Grade (%) | 91.08 | 78.88 | 76.27 | 81.94 | (A, B), (A, C) |
| Exam Grade (%) | 76.62 | 63.37 | 60.82 | 66.82 | (A, B), (A, C) |
| Total Grade (%) | 90.16 | 77.82 | 71.88 | 79.51 | All |
| Final Grade (0-20) | 17.67 | 15.25 | 13.80 | 15.46 | All |
| Attendance (%) | 98.02 | 97.02 | 86.03 | 92.65 | (A, C) |
| Lecture Attendance (%) | 99.48 | 99.22 | 90.42 | 95.54 | None |
| Downloads (#) | 427.83 | 450.50 | 344.13 | 397.14 | None |
| Slide Downloads (#) | 85.92 | 62.50 | 73.13 | 75.09 | None |
| Posts (#) | 36.58 | 22.88 | 16.67 | 24.91 | (A, C) |
| First Posts (#) | 4.92 | 1.63 | 2.00 | 2.91 | None |
| Reply Posts (#) | 31.67 | 21.25 | 14.67 | 22.00 | (A, C) |
| Challenge Posts (#) | 18.08 | 12.00 | 9.47 | 13.00 | (A, C) |
| XP from Challenges (%) | 97.37 | 89.47 | 72.46 | 84.89 | (A, C) |
| Theoretical Challenge Posts (#) | 12.42 | 6.75 | 6.27 | 8.49 | (A, B), (A, C) |
| XP from Theoretical Challenges (%) | 98.15 | 87.50 | 75.93 | 86.19 | None |
| Lab Challenge Posts (#) | 5.67 | 5.25 | 3.20 | 4.51 | None |
| XP from Lab Challenges (%) | 96.67 | 91.25 | 69.33 | 83.71 | (A, C) |
| Quest Posts (#) | 5.25 | 1.50 | 1.33 | 2.71 | (A, B), (A, C) |
| XP from Quests (%) | 98.00 | 24.50 | 36.53 | 54.86 | (A, B), (A, C) |
| Badges (#) | 38.17 | 29.63 | 21.67 | 29.14 | (A, C) |
| XP from Achievements (%) | 78.24 | 60.32 | 49.63 | 61.88 | (A, B), (A, C) |
| Completed Achievements (#) | 11.75 | 8.50 | 5.20 | 8.20 | (A, C) |
| Explored Achievements (#) | 17.67 | 14.00 | 12.07 | 14.43 | (A, B), (A, C) |
| [A] Postmaster | 2.00 | 1.25 | 0.67 | 1.26 | (A, C) |
| [A] Bookworm | 3.00 | 3.00 | 2.73 | 2.89 | None |
| [A] Proficient Tool User | 2.83 | 2.63 | 1.87 | 2.37 | (A, C) |
| [A] Rise to the Challenge | 2.67 | 2.25 | 1.87 | 2.23 | None |
| [A] Attentive Student | 2.58 | 2.25 | 1.20 | 1.91 | (A, C) |
| [A] Class Annotator | 2.25 | 1.88 | 0.60 | 1.46 | (A, C) |
| [A] Challenger of the Unknown | 2.50 | 0.63 | 0.73 | 1.31 | (A, B), (A, C) |
| [A] Lab Master | 1.33 | 0.38 | 0.67 | 0.83 | (A, B) |
| [A] Wild Imagination | 1.00 | 0.88 | 0.80 | 0.89 | None |
| [A] Right on Time | 2.83 | 2.75 | 1.93 | 2.43 | (A, C) |
| [A] Amphitheatre Lover | 2.83 | 2.75 | 2.20 | 2.54 | (A, C) |
| [A] Lab Lover | 2.75 | 2.38 | 1.93 | 2.31 | None |
| [A] Popular Choice Award | 1.58 | 1.38 | 0.40 | 1.03 | (A, C) |
| [A] Hollywood Wannabe | 2.17 | 1.75 | 1.40 | 1.74 | None |
| [A] Presentation Zen Master | 1.00 | 1.00 | 1.00 | 1.00 | None |
| [A] Golden Star | 1.33 | 0.88 | 0.80 | 1.00 | None |
| [A] Lab King | 0.42 | 0.00 | 0.27 | 0.26 | None |
| [A] Presentation King | 0.25 | 0.13 | 0.13 | 0.17 | None |
| [A] Exam King | 0.17 | 0.00 | 0.00 | 0.06 | None |
| [A] Course Emperor | 0.08 | 0.00 | 0.00 | 0.03 | None |
| [A] Quiz King | 0.17 | 0.13 | 0.00 | 0.09 | None |
| [A] Quizmaster | 0.33 | 0.13 | 0.00 | 0.14 | None |
| [A] Good Host | 2.08 | 1.25 | 0.47 | 1.20 | (A, C) |

*Figure 5. Cluster performance data. Each row represents a measurement, where the first three columns represent a clusters. Green cells denote the maximum value, red the minimum value, and yellow a value in between. The fourth column shows the clusters between which significant differences were observed.*

more posts than other clusters on Theoretical Challenges, and also collected more XP. The same was observed for Lab Challenges, with significant differences only observed for acquired XP, and only compared to cluster C.

As for Online Quests, Achievers also contributed significantly more than other clusters. They posted more than other clusters and also were awarded more XP for doing so, and these differences were significant. Indeed, the other clusters' participation was almost negligible, as students from cluster A contributed with an average 5.25 posts per student and received 98% of the XP assigned to Online Quests, while students from cluster B and C made on average 1.5 and 1.33 posts and received only 24.5% and 36.5% of the allocated XP.

Cluster A students also excelled on achievements, acquiring more XP than any other cluster. Furthermore, these students also collected more badges, even though this was only significant as compared to cluster C, and they also completed more achievements than other clusters (i.e., achieved the last level), with this value being more than twice that that of cluster C. Furthermore, they also explored more different achievements than other clusters. Regarding each achievement independently, cluster A collected more badges per achievement than others, even though significant differences in comparison to all clusters were only observed for the achievement "Challenger of the Unknown". Compared to cluster B, significant differences were observed for the achievement "Lab Master", and compared to cluster C, for the achievements "Postmaster", "Proficient Tool User", "Attentive Student", "Class Annotator", "Right on Time", "Amphitheatre Lover", "Popular Choice Award" and "Good Host". There were two achievements for which all clusters participated similarly. The "Presentation Zen Master", where all students acquired the only badge available, and the "Bookworm", where all students from clusters A and B and most of cluster C got the 3$^{rd}$ level badge.

Of the 12 students from cluster A, 11 responded to the questionnaire. Taking into account the responses' modes and respondent percentage for those modes, most students considered the gamification experiment performed very well (4, 55%) [1-terrible; 5 - excellent]. Compared to other regular courses, students found our gamified course to be more motivating (5, 91%), more interesting (4, 64%), to require more work (4, 64%), as not being more difficult (3, 55%), and to be easier to learn from (3 and 4, 36%) [1-Much less; 5 - Much more]. Also, compared to other courses, students classified the amount of study performed in this one as being in greater quantity (4, 45%) and being more continuous (4, 64%) [1 - Far Less; 5 - Far More]. Cluster A students found that they were more playing a game than just attending a course (4, 45%) [1 - Not at all; 5 - A lot], and they considered that achievements should not account for a higher part of the grade (2, 36%) [1-definitely not; 5 - definitely yes]. Students also found that when faced with non-mandatory tasks that would earn them an achievement, they did them more for the game's sake then for the grade's (4, 36%) [1-grade only; 5 - game only], and they thought that achievements that required extra actions, such as "Class Annotator", "Quests" and "Theoretical Challenges", contributed to their learning experience (4, 45%) [1-Not at all; 5 – definitely]. This cluster also considered that it was a good idea to extend gamification to other courses (5, 55%) [1-definitely not; 5 - definitely yes]. These students were also asked a question regarding game balance. They were asked if 1) the game should keep having diminishing returns per achievement level (first level worth more), if 2) all levels should be worth the same XP, or 3) if the first levels should be worth less XP. Students from cluster A considered that the game should keep the same XP distribution per level (1).

Cluster A students made a few suggestions that stood out from the rest of the students. Two students from this group suggested that customizable avatars and items could be used to improve game immersion, and another student suggested what may be called an achievement tree – something that required the students to unlock achievements in a precedence tree. Three of these students also suggested that oral participation should be rewarded. Cluster A students also seem to have enjoyed more the achievements "Lab Master", "Quizmaster" and also "Quiz King", "Lab King", "Presentation King", and "Exam King", which comes as no surprise given that they excelled at them.

These students also made some interesting suggestions to improve the leaderboard. For example, one pointed out that the leaderboard could suggest an achievement or task whose completion would allow the student to transit to the next level. Tools like comparison charts and statistics were also proposed, to spur competitiveness and promote progress assessment.

### Cluster B

This cluster was composed by 8 students. They had their mean final grade and mean grade for every evaluation component situated between that of cluster A (on top) and cluster C. Even though differences for the final grade were statistically significant compared to the other two clusters, differences regarding all evaluation components, except for quizzes, were only significant in comparison to cluster A. Both theoretical lecture and overall lecture attendance were very close to that of cluster A, but these differences were not significant.

Regarding online activity, while cluster B students performed the most downloads of course materials, they downloaded the least lecture slides, even though these would earn them XP, but these differences were not significant. Students from cluster B made an average amount of posts, and by breaking them down into first and reply posts, we observed that these students performed an average number of reply posts, just below cluster A, but they have also made the least first posts, represented by a low number, very close to that of cluster C. Even though these differences were not significant, this suggests that these students were not very proactivity.

Cluster B students had an average performance on Challenges and Online Quests. Despite presenting a rather low amount of challenge posts, much lower than cluster A, and almost as low as cluster C, they acquired a rather high amount of XP from challenges. By breaking these into lab and theoretical contributions, we found that this low-post-high-xp effect was only observed for Theoretical Challenges. However, in lab challenges, cluster B students made rather high amounts of posts and acquired a high sum of XP. As for Online Quests, students from cluster B performed rather few posts, almost as few as cluster C. Still, they acquired the least amount of XP from this element.

Students from cluster B had a mild performance on achievements. They acquired significantly less XP than cluster A, but more than cluster C, even though this difference was not significant. They collected and average number of badges, and they completed and explored and average number of achievements, despite these differences not being significant too. For most achievements, cluster B presented an average number of acquired badges, but there were a few exceptions. They acquired the fewest badges for "Challenger of the Unknown" and for "Lab Master", and these numbers were only significant compared to cluster A. As a matter of fact, the values were rather close to those of cluster C.

Of the 8 students from cluster B, 5 replied to the questionnaire. Taking into account the responses' modes and respondent percentage for those modes, most students recognized our gamification experiment as performing very well (4, 80%) [1-terrible; 5 - excellent]. Compared to other courses, students considered our course to be more motivating (4, 80%), more interesting (4, 100%), as not requiring more work (3, 60%), nor being more difficult (3, 80%), and as not being harder nor easier to learn from (3, 60%) [1-Much less; 5 - Much more]. Also, students classified the amount of study performed in the course as having the same quantity (3, 80%) but being more continuous than other courses (4, 80%) [1 - Far Less; 5 - Far More]. Cluster B students found that they were playing a game as much as they were attending a course

(3, 60%) [1 - Not at all; 5 - A lot], and they considered that achievements should account for a higher part of the grade (3 and 4, 40%) [1-definitely not; 5 - definitely yes]. Students also found that when faced with non-mandatory tasks that would earn them an achievement, they did them more for the grade's sake then for the game's (2, 80%) [1-grade only; 5 - game only], and they thought that achievements that required extra actions, such as "Class Annotator", "Quests" and "Theoretical Challenges", contributed to their learning experience (4, 60%) [1-Not at all; 5 – definitely]. Students in this cluster considered that it was a good idea to extend gamification to other courses (4, 40%) [1-definitely not; 5 - definitely yes]. When faced with the question regarding the XP distribution system, students from cluster B considered that the last levels of the game should earn them more XP than the first ones (3).

Students from cluster B made some interesting suggestions to improve game illusion. One student suggested that there should be more class achievements to get all students to collaborate. For example, if everybody would have above 80% on a quiz, everybody would get a bonus. On the other hand, another student stated that more ways to compete should be added to the experience, to make it more challenging. These students also suggested that the leaderboard should allow for Avatar customization, and that further options should be unlockable.

## Cluster C

Cluster C was composed by 15 students. These presented the lowest grades on all evaluation components, but these differences were only significant as compared to cluster A. Consequently, they also had the lowest final grades in comparison to all clusters, and they attended the fewest lectures, although this was only significant compared to cluster A ($p < 0.05$).

Students from cluster C presented online activity patterns closer to cluster B. While this cluster downloaded the fewest resources, it downloaded more lecture slides than cluster B, but fewer than cluster A, although none of these differences are significant. These students also made the least posts of all clusters, but this was only significant compared to cluster A. Cluster C students performed, in average, slightly more first posts than cluster B, even if both values were very close. As for replies, they made the least posts here, and this is significant in comparison to cluster A. This suggests theses students were the least participative.

Cluster C made the least challenge posts per student and acquired the least XP, even if this was only significant compared to cluster A. The same effect was observed for Theoretical Challenges and Lab Challenges, but significance was only observed for the number of posts in theoretical challenges, and the amount of XP acquired from lab challenges, as compared to cluster A. In terms of contributions to the Online Quests, these students made the least posts, even though this number was really close to that of cluster B and thus, significance was only observed when compared to cluster A. However, these students grabbed a greater chunk of XP from this element than cluster B, but it was still less than half of what students from cluster A got.

Cluster C had the poorest performance in terms of achievements. They acquired less XP than other clusters, but this was only significant compared to cluster A. They also acquired less badges, and completed and explored less achievements and again, this was significant as compared to cluster A only. For most achievements, these students acquired the least amount of badges. The exceptions were "Challenger of the Unknown", "Lab Master", "Lab King", and "Presentation King", where the amount of badges were slightly above that of cluster B.

Of the 15 students from cluster C, 12 replied to the questionnaire. Taking into account the responses' modes and respondent percentage for those modes, most students recognized our gamification experiment as performing very well (4, 50%) [1-terrible; 5 - excellent]. Compared to other courses, students considered our course to be more motivating (4, 50%), much more interesting (4 and 5, 42%), as requiring more work (4, 50%), but not being more difficult (3, 67%), and as not being harder nor easier to learn from (3, 50%) [1-Much less; 5 - Much more]. Also, compared to other courses, students classified the amount of study performed in this course as having the same quantity (3, 50%) but being more continuous (4, 50%) [1 - Far Less; 5 - Far More]. Cluster C students found that they were playing a game as much as they were attending a course (3, 42%) [1 - Not at all; 5 - A lot], and they considered that achievements should definitely not account for a higher part of the grade (1, 33%) [1-definitely not; 5 - definitely yes]. They also found that when faced with non-mandatory tasks that would earn them an achievement, they did them more for the game's sake then for the grade's (4, 42%) [1-grade only; 5 - game only], and they thought that achievements that required extra actions, such as "Class Annotator", "Quests" and "Theoretical Challenges", contributed to their learning experience (4, 33%) [1-Not at all; 5 – definitely]. Students in this cluster considered that it was a good idea to extend gamification to other courses (5, 50%) [1-definitely not; 5 - definitely yes]. When faced with the question regarding the XP distribution system, students from cluster C considered that the system should remain as it was (1).

Students from this cluster suggested that game illusion could be improved by better integrating lab classes with the gamified experience, by using XP to buy items that could influence gameplay, and by simply adding new achievements and badges.

In general, students from all clusters have shown concerns related to posts being rewarded by numbers and not by quality. Also, many students acknowledged that the game was indeed competitive, but many still asked for more opportunities to compete, in order to have a more challenging experience. Most students also considered achievements like "Rise to the Challenge" and "Proficient Tool User" to be very successful because it allowed them to put in practice what they have learned in the lectures and in lab classes. They have also enjoyed "Right on Time" and "Amphitheatre Lover", because it encouraged them to attend classes. Conversely, they did not enjoy achievements like the "Bug Squasher", because it was too much work for too little XP, the "Attentive Student", because finding bugs on lecture slides was a tedious task, and the "Postmaster", because it encouraged them to post more in disregard for quality.

## DISCUSSION

Our analysis allowed us to identity three types of students of the MCP course. Ultimately, they can be viewed as different tiers of students, distinguishable by incremental levels of participation and performance. But as we delve into the data, these three types become rich representations of possible ways of experiencing a gamified course. In order to enrich our knowledge about the dynamics of these clusters, here we will answer two questions: 1) What tells these clusters apart? What characterize each and every type of student? And 2) How can the gamified experience be tailored to improve the experience of each cluster?

### What tells them apart?

#### *Cluster A – The Achievers*

Cluster A was mainly composed by students that grabbed every chance to get some additional XP, and this is easily observable in Figure 4, where their mean XP per day line seems to be always ahead. These students had the best grades, attended the most classes, downloaded the most lecture slides (because these would earn them something), were the most participative and proactive, and completed every achievement they could get their hands on. And for all these

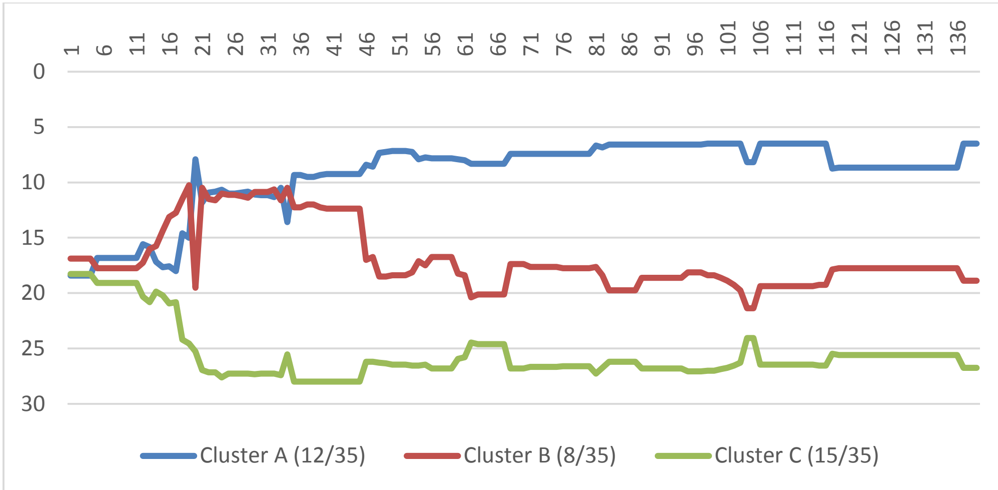


*Figure 6. Average student leaderboard rank per day.*

reasons we named them *Achievers*. They strived to complete all achievements and be better than others, which is corroborated by their constant dispute for the top positions on the leaderboard (see Figure 6). These students loved the competition and they actually asked for more of it.

Of all clusters, Achievers were the only ones reporting that they felt they were actually playing a game rather than just attending a course. They also had the highest value regarding how much more motivating they have found the course to be, and they were the only cluster reporting that they though the course easier to learn from. This leads us to think that Achievers were really engaged by the course and actually took advantage of what the gamified experience had to offer.

### *Cluster B – The Disheartened*

Students from Cluster B had average-to-low grades, closer to those of cluster C than that of cluster A, but they had high attendance levels, more similar to cluster A. And even though they have downloaded the most course materials, they did not download enough of those that would actually earn them XP. This suggests that students from this cluster did not like to read slides, and even an XP reward was not enough to make them do so. Or, perhaps, the reward was not up to the task. These students had an average level of participation on Moodle, something between cluster A and C, but they were not very proactive, just like cluster C. Although they presented average contributions on most achievements, they were actually the worst performing students on the Online Quests.

At first glance, cluster B looks just like a transition stage, between A and C. However, Figure 6 tells us a different story. During the first 6 weeks students from cluster B were actually competing with cluster A, and this is also apparent in Figure 4. It was like if there were only two clusters, two different tiers of students. However, around day 45, when the third quiz came in, the status quo changed, and cluster B students started to lose their ground and never recovered. Because of this we named this cluster the *Disheartened* students.

Cluster B responses to the questionnaire were in great part similar to those of cluster C. However, there were a few nuances that are worth mentioning. For example, students from this cluster considered that they did non-mandatory tasks that would earn them an achievement more for the grade's sake than the game's, but the other two clusters were not of the same opinion. Furthermore, these were the only students that considered that the XP distribution for the achievement levels should change. These two issues suggest that these students were not indeed satisfied with the gamified experience.

*Cluster C – The Underachievers*

Cluster C students had the lowest grades and attended the fewest lectures. They have also downloaded the least course materials, but downloaded more lecture slides that cluster B, which suggests that they at least took advantage of easier opportunities to grab XP. These students also had a low level of both participation and proactivity, and they performed poorly for most achievements, with the notable exception of the Online Quests. Here, they performed better than the Disheartened students, but they fell short compared to the Achievers. This cluster seems to be the opposite of cluster A: they did not seem to care about completing achievements, being better than the other players, or any particular aspect of the course. This finding seems to be corroborated by their lack of feedback on open-ended questions and by presenting a large questionnaire response abstinence (80%). For this reason, we decided to name these students the Underachievers.

The questionnaire feedback from these students was similar to that of cluster B. As a matter of fact, in some points it seemed to reflect a deeper engagement with the course. Similarly to the Achievers, the Underachievers considered that they did non-mandatory rewarded tasks more for the game's than the grade's sake, and they also found that the XP distribution for the achievement levels should remain as it was. This suggests that these students actually enjoyed the course, but it was still just a course.

## How to Improve Their Experience?

The Achievers were highly motivated students and they tried to squeeze the most out of the gamified experience. The most effective and ineffective achievements seem to have been consensual among clusters, but these students seem to have grew fond of achievements like "Lab Master" and "Exam King". We believe this happened because these "Master" and "King" achievements gave them further recognition for their feats. Achievers were the only type of student that actually participated substantially on the Online Quests. This might mean one of two things: either Quests do appeal mostly to Achievers, or Achievers only participated because they participate in everything. In fairness, both can be true, but additional studies are required to better understand this subject.

Even though it seems that Achievers do not need anything more to play the MCP game and take advantage of it, they have proposed a few interesting additions that could make the course more engaging for them and for other student types as well. The addition of customizable avatars, items and even a virtual world, for instance, could be used to improve their creativity and develop a sense of identity with the course. On the other hand, the inclusion of an achievement precedence tree, were students had to complete tasks to unlock certain achievements, would help them feel more autonomous and in control of their learning experience, by allowing them to choose their own learning path. The addition of achievements to reward oral participation in class could also be used to promote discussion among students and help better understand the taught subjects.

The Disheartened students are probably the most particular student type, because their behavior was not constant over the term – they got disengaged mid-course and did not recover. We do not know for sure what made them disengage, and further research is required to fully understand this matter. However, we hypothesize that the increasing workload of other courses might have driven the students' attention away from our course, and this was particularly noticeable for Disheartened students, given that their engagement was potentially lower than that of the Achievers. It was also not clear whether these students did not even try to recover at all or simply did not get a second chance, given that most of the Challenges and Online Quests occurred during the first half of the term. It is plausible that these students might have realized they were left behind at some point, and that they had a lot of lost XP to catch up. But it might have been too late for them. Clearly this is a potential problem that must be addressed in future versions of the course. Challenges must be plenty and well distributed over the term, in order to give just enough opportunities for them to turn the game around. Disheartened students also requested the addition of achievements to promote collaboration. We believe these achievements could be particularly useful to help Disheartened students to keep up with the course, and to further engage Underachievers.

The Underachievers seem to lack any particular interest in the course. We believe these students can be further engaged my adding most of the elements aforementioned, which would render the experience more fun. Furthermore, given that these students seem to be only concerned with getting their grades in “just another course”, the balance of the game should be tuned to guide their efforts and discourage procrastination.

## CONCLUSIONS AND FUTURE WORK

Gamification of education is still taking its early steps, but empirical results already seem promising. Previously, we have presented an experiment in which we have gamified a college course, by adding diverse game elements, like points, badges, levels and leaderboards, and by shaping course activity into meaningful challenges and quests. In this article we described a study in which we analyzed how students acquired experience points (XP) over the semester, and identified behavioral patterns regarding how students experienced the gamified course. With resort to cluster analysis, we have discovered three types of students: 1) the Achievers, students that tend to excel at everything and that grab any opportunity they can to get additional XP; 2) the Disheartened students, which seem to start as motivated as the Achievers, but soon grow tired of the game and stop trying hard, which has a negative impact in their results; and 3) the Underachievers, students with below average results, who seemingly do not care enough and appear to just be taking another course. We have provided an extensive description about each type of student and suggested a few guidelines, which should be taken into account when designing gamified learning experiences for them.

As for future work we would like to collect further data to enrich our knowledge about these three student types. In particular, we feel that the Disheartened and the Underachiever students are not yet very well understood, and we believe that the missing data could be retrieved with the help of open interviews, and by using questionnaires to measure student engagement and identify potential gamer types.

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