

# Evaluating the use of gamification in mathematics learning in primary school children

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**Abstract**—This paper presents a practice developed for elementary education students (3<sup>rd</sup> grade). We used gamification to build a game based on the students' profile (players) in math classes. Gamification is the use of game elements and game principles in non-game contexts [1]. The use of gamification in the educational context is a practice that brings the playfulness of the gaming world to the classroom and promotes the engagement and motivation of newer generations [2]. We used the Octalysis structure proposed by Yu Kai-Chou [3] to model and project the students' profile and the gamification itself. We observed and measured students' experiences as players on the game: the achievement of icons to advance in the levels, their strategies to achieve the goals and their involvement on the learning process. Players interact collaboratively and develop skills and competences interacting in the same shared space. The results show that use of the game, as an initiative to empower students, creates meaningful relationships on the students' learning process.

**Keywords**—gamification, mathematics teaching, primary school

## I. INTRODUCTION

This article presents practices developed when applying gamification strategies to build a concrete game based in students' profiles to be used in some of math class with students of the tree years of elementary school. Gamification is the application of game elements and principles in non-game context [1]. The use of gamification in education context is an innovative practice that brings the playfulness of the games to classroom, promotes engagement and motivation in the new generation, considering the skills with tools and digital devices that this new generation have [2, 4].

We used the structure provided by the Octalysis framework [3] to model and project the students profile and the gamification itself where the student lives like a player to win icons so he can advance elaborated levels for objectives proposed as the protagonist of their own learning. The players interact in a collaborative way playing in groups and developing skills and competences by the interaction in the shared space.

The contribution of this work is the evaluation of the impact that the use of gamification generates in math learning with kids of the first years of elementary school.

The experiment was accomplished in the diversified environment of a classroom and in that way was possible to innovate the pedagogical practice that was applied with gamification's strategies created by the students' progression with the goal of improve the education quality. The game

happened weekly in two different classrooms following the didactical book strategies (numbers and operations, space and geometric shapes, measures and information processing) with students between 8 and 9 years in the same school.

The remainder of this paper is organized as follows: section 2 presents the related works, section 3 presents the game proposal, section 4 presents the tests and the results obtained on the use of the game on two classrooms, and finally, section 5 presents some conclusions.

## II. RELATED WORK

McGonigal [5] proposed four characteristics for the game: goal, rules, feedback and voluntary participation. The goal provides a sense of purpose. The rules impose limitations on how players can achieve the goal. The feedback system tells players how close they are to reaching the goal. The voluntary participation requires that each of the players consciously and voluntarily accept the goal, the rules and the feedback. It is a general overview of a game engagement process. She does not detail how game technics could be used to archive engagement.

The Octalysis framework defines eight core drives as a basic human motivation [3], they are: Epic Meaning & Calling, Development & Accomplishment, Empowerment of Creativity & Feedback, Ownership & Possession, Social Influence & Relatedness, Scarcity & Impatience, Unpredictability & Curiosity and Loss & Avoidance. Chou proposes a framework to map and use game technics to engage player on a gamification.

Morschheuser et al [6] developed a gamification process by synthesizing the current body of literature on gamification and interviewing 25 gamification experts. The result is a process divided into seven phases: project preparation, analysis, ideation, design, implementation, evaluation and monitoring.

Fredericks et al [7] present three types of engagement: emotional, behavioral and cognitive, each type of engagement has different indicators. It is an extensive analytic study, but do not explore how to promote the engagement.

## III. THE GAME CONSTRUCTION

We developed and played a game in the classroom environment named Study Spacecraft (sCraft). The game was built based in games elements and mechanisms of Octalysis' gamification [3] that contains dynamics, rules, levels and awards

with the playfulness of the games and applied with the teacher's mediation to systematize the math learning.

In the game, the students would be the players and the protagonists of their own learning, with voice and autonomy, with freedom to produce and share their knowledge with their team and considering their own learning pace. Each player when performing the proposed activities in the textbook can get a bonus that could be changed in icons with specific functions based in the motivation of the player and annexed in the study spacecraft in a paper card. The language used during classes would be a gaming narrative.

The methodology used was the construction sCraft game with the students' participation and the help of the strategies of the Octalysis framework [3] and a simplified version of the Morschheuser et al [6] gamification process.

The eight core drivers from the Octalysis framework [3] are:

1. Epic Meaning & Calling represents motivation that a person is meant for doing a certain thing, like he was chosen.
2. Development & Accomplishment is related to development of skills, challenges and progressions.
3. Empowerment of Creativity & Feedback by engaging the user in a creative process, he can design different strategies with the elements available to overcome challenges in his own preferred way.
4. Ownership & Possession by owning something, a user care for and make it better.
5. Social Influence & Relatedness core drive related to social elements that drive people. Group activity, influence and other activities that makes people feel related to someone, some group or some place.
6. Scarcity & Impatience is related to opportunity and deadline, like wanting something that you can't have, or the need someone feels to acquire or do something because it is a onetime opportunity.
7. Unpredictability & Curiosity are strong drives that makes a person constantly engaged to think about what it could be or what could happen if.
8. Loss & Avoidance makes use of the feeling of possibility of loss to engage the user into doing, or not, something, and therefore, not losing it.

As well as the use of the game in some classes to motivate and engage students in learning mathematics with the activities proposed in the textbook.

The gamified game was constructed from the application of a gamification construction process [6] in the following steps:

1. Identification of the contents of the mathematics area to be gamified. It has been identified that the learning of mathematics by students is the goal of the gamification to be constructed.

2. Identification of the profile of the target audience. The profile was identified from the teachers' experience observing what motivates each student.
3. Gamification project. The Octalysis framework was chosen as the base model to design the gamification that will be constructed.
4. Scenario selection for implementation. It was chosen a scenario that allowed the creation of the sCraft classroom game. The game contemplated the game techniques anticipated in the chosen gamification project.

Icons were created in the game and have specific functions. They link Octalysis' Core Drives and implicit / explicit motivations [8, 9] accordingly:

- Armor icon indicates an Ownership & Possession core driver and is used to protect player's own icons.
- Bomb icon indicates a Loss & Avoidance core. Its function is to take possession of a player's icon.
- Key icon indicates a Development & Accomplishment core and is used to advance a level of the game.
- Heart icon indicates a Social Influence & Relatedness core driver. It enables the player to earn bonus and distribute them to friends.
- Diamond icon indicates both Ownership & Possession and Scarcity & Impatience core drivers. The player wins an honor medal.
- Magnifying glass icon indicates an Unpredictability & Curiosity core. The player wins a treasure map that leads to a freebie.
- Hammer indicates an Empowerment of Creativity & Feedback core driver. The player uses it to create an avatar for the spacecraft.
- Spaceship Assistant Card is an Epic Meaning & Calling core driver and is used by players to help others that have difficulty to complete the game.

A game language nomenclature has been developed to "unplug" players from the real world [2]. Traditional classroom nomenclatures have been replaced and became: Discipline = game, class = battle, student = player, teacher = scribe, monitor = ship assistant, activities = phase, development = level, book = Conquest field, portfolio = study spacecraft (sCraft), double / group = ships coupled.

On the mural of the room the values and functions of the icons were attached, during the conquests the students performed the tasks in group and only at the end of the class they earned their bonifications, purchases of the icons and battles.

A game environment was built in the classroom because the playfulness naturally induces motivation and fun, where each child placed a cardboard base in the desk's portfolio, transforming it into their spaceship, the base of the ship had a

Space to attach the icons that were earned with the bonuses received after completing the tasks.

The pages of the textbook came to be called the field of conquest and each page resolved the player received a reward bonus. It was used a monetary system (\$1, \$2, \$5, \$10 and \$20), with toy money to create situations of daily life and contribute with interventions for citizen training. The classroom was organized according to the position that the players established with the ships coupled. At the teachers' table were the icons, bonuses and cards of the ship's assistant.

#### IV. TESTS AND RESULTS

For a year, the sCraft game was applied to 49 students from 8 to 9-years-old from for 3<sup>rd</sup> elementary grade of the same school. They were divided on two math classes. Each class (identified as A and B) has a different teacher, the same content and occurs at the same time at different classrooms.

The evaluation used the feedback of the activities' correction before moving to the next level of the game. Student's participation in the sCraft game demonstrated the individual evolution of each player in achieving the learning objectives proposed by the teacher in the phases of the game.

Table I shows the icons' summary earned the 49 students that played sCraft.

TABLE I. SUMMARY OF ICON USAGE

<i>Icon</i>	<i>Class A</i>	<i>Class B</i>	<i>Total</i>
Armor	24	28	52
Bomb	22	46	68
Key	72	41	113
Heart	88	75	163
Diamond	17	16	33
Magnifying glass	166	118	234
Hammer	34	32	66

The results evaluates the motivation and the profile of each player in the sCraft game, through the icons chosen by each student. When they conquered the icons, the students presented joy, motivation and involvement in a collaborative way being inserted in the game environment.

When analyzing the results of the table of the icons conquered by the students of classes A and B in level 1, it was notorious the preference of the players by the icon Magnifying glass in the two classes surveyed, where the player conquered parts of a map of the treasure which would lead to a surprise toast, this icon presented the motivation of unpredictability and curiosity.

The students demonstrated an extrinsic motivation when they wished to win gifts. The search for the heart icon was much sought after by the players to have as motivation the social influence and belonging and to give right to earn bonuses to distribute to the friends, developing the collaboration and the

spirit of solidarity in the game. Group B was more interested in winning the icon bomb that gave the right to take possession of icons of other players and had as motivation the loss and rejection.

We noticed an equivalence in the number of hammer and diamond icons in the two classes. The diamond icon gave the right to a medal of honor, with the motivation of ownership, possession, scarcity, impatience. The hammer icon gave the right to create avatar for the ship and the related motivation was that of empowerment and feedback.

The players who were most motivated in classes A and B during the game were those who showed more interest in the key icon, this icon presented as a motivation the development and achievement and the right to the player who won seven keys to advance in the game phase.

The armor icon was used differently: in class A armor was sufficient for protection during all matches, in group B the armor icon lost its function after being bombed and it was necessary to acquire it again to protect itself.

To evaluate the perceived motivation, we elaborate a questionnaire to be answered by the students' parents. The questions are:

1. Do you see your child motivated to attend classes on the days of sCraft?
2. Do you see if your child is taking better ownership of the values of money bills (monetary system)?
3. Do you see if your child is more autonomous in carrying out the activities, not waiting for the answers ready, more trying to solve them?
4. Do you see if your child's learning occurs in a more motivated way?
5. Do you see if your child is more collaborative in daily tasks?
6. Do you see if your child has shown an interest in reading story books to participate in the N.E.
7. Do you see the joy in your child for the lessons with game sCraft?
8. Do you see if your child talks more to friends about school?
9. Do you see if your child has been more interested in solving math-related activities than other subjects?

We used a five-level Likert scale [10] for each question: (1) Strongly disagree, (2) Disagree, (3) Neither agree nor disagree, (4) Agree and (5) Strongly agree.

Table II showed the results obtained from the questionnaire sent to the families of the students on class A.

TABLE II. CLASS A RESULTS

Question	Five-level Likert scale				
	1	2	3	4	5
Q1	0	0	2	4	14
Q2	0	0	0	6	14
Q3	0	0	3	10	7
Q4	0	0	3	5	12
Q5	0	0	5	8	7
Q6	0	2	1	9	8
Q7	0	0	2	2	16
Q8	0	0	5	5	10
Q9	0	0	3	7	10

Table III showed the results obtained from the questionnaire sent to the families of the students on class B.

TABLE III. CLASS B RESULTS

Question	Five-level Likert scale				
	1	2	3	4	5
Q1	0	0	0	3	12
Q2	0	0	0	3	12
Q3	0	0	0	5	10
Q4	0	0	0	2	13
Q5	0	1	0	4	8
Q6	0	0	2	2	11
Q7	0	0	0	3	12
Q8	0	0	0	6	9
Q9	0	0	0	2	13

Both tables II and III shows the parents perception that the students developed skills and are engaged on activities at home and at school.

The results showed that the use of gamification in the early years promotes engagement and motivation in students, also improve learning for this audience.

Using sCraft the students make discoveries, play, construct and learn. Math classes have become more engaging and fun, students have learned in a motivationally way with the playful and challenging environment.

## V. CONCLUSION

The results point out a positive trend in the use of the strategies of the games with students of the initial years.

The learning developed in a pleasant and effective way, with playfulness in the acquisition of new knowledge. This game created an environment where children engaged in the language of games in a fun and attractive way with improved learning in the cognitive, affective, socio-cultural, among others; in a democratic, collaborative and interactive educational model.

The use of gamification outside the game world influences behavior and engages students in a meaningful and motivating way, leads to an approach such as what occurs in games, and how individuals in this culture are more accustomed to interacting with problems and to solve them by building their knowledge.

The sCraft game promotes important contributions of how to intervene in problems of learning, motivation and engagement of the students with a playful and attractive teaching. Gamified strategies activate the motivations to make teaching a challenging experience to intervene in the school reality, involving respectively the authors as protagonists of the learning teaching process.

Learning math using the sCraft game was a most enjoyable and innovative way to teach. Gamification in the classroom gives the school a chance to recreate itself.

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