

Learning Gains, Motivation and Learning Styles in a Gamified Class*

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This work presents the results of the implementation of a gamification system to two classes in a database course for engineering on computational technologies students. The results are obtained from a pretest-posttest methodology in a focus group with 20 students and a control group with 20 students. This study was made during a whole semester and the analysis comprises learning gains and the students' grades. The study shows that learning gains in both groups are similar but in analysis, it is stated that both groups have specific characteristics that point to advantages in the implemented gamification system and that propose new research questions in the subject. On the other hand, the analysis on learning styles is complemented with a study on motivation aspects that have supported the students' learning process. This work presents a new perspective on research over the learning technique because the majority of the studies published explore the relationship only between game characteristics and motivation, in contrast the present research offers the advantage of an experimental design over a whole semester in terms of learning gains and learning styles.

Keywords: gamification; learning gains; motivation; learning styles; engineering education

1. Introduction

Nowadays, there is a big discussion over the differences between coexistent generations in society. A main characteristic of millennials [1] is their wide use of technology and their predominant cultural traits in terms of information access and communication. Also, the technological advances have unlocked new horizons in education. Some examples of learning technologies emerged from this new horizons are learning environments enriched by the use of technological education resources [2, 3], hybrid courses [4], massive open online courses [5, 6], mobile learning [7], challenge based learning (CBL) [8], flipping the classroom [9–10] and gamification [11–13]. Gamification is a new field that uses game elements to enrich non-game environments. Also, the inherent nature of games is based on persuasion, voluntary participation and the search of an objective so games impulse players by elements of seduction or election in a non-coercive way. These elements even help motivate specific behaviors in activities like rehabilitation like in [14] or in education like in [15]. Gamification uses these elements to increase motivation. Motivation could be a difficult aspect sometimes when students don't find a clear objective or reason for the process. This technique is helpful to design learning experiences based on elements as points, levels, badges, leader boards, progress indicators and feedback to

stimulate students to be active and participative in their learning.

Under the perspective of the educational needs and tendencies mentioned before, the hypothesis of this work states that the introduction of the gamification technique will increment the learning gain of students in a database class compared to other students in the same course without the use of the technique.

The objective of the research is:

1. Quantify the effect of gamification over the learning process compared to a traditional course considering:
 - (a) The learning gain observed by a pretest-posttest methodology
 - (b) The average of partial evaluations grades, final project grades, final exam grade and final grades
 - (c) The intrinsic and extrinsic motivation supported by the methodology

In this study, the gamification implementation from the point of view of learning has been related to the concept of motivation because it is an strategy that orientates students to the achievement of their learning objectives by means of the design of stages, rules and other stimuli that make students involved in their own learning and that detonate and maintain motivation as stipulated in [16]. In its theory of autodetermination, [17] says

that intrinsic motivation—motivation that appears spontaneously in a person—and extrinsic motivation—motivation that pushes to action from the exterior—are process that take part in the learning process and preferences in students. The most important part of this theory is that motivation is not a static phenomenon but students grow achieving autoregulation and autodetermination. This process occurs when students are supported by the context or learning experiences that allow them to develop skills as autonomous and competent persons. Motivation that has contingent place in the introduction of a gamification methodology will influence the development of intrinsic motivation and autoregulation or autodetermination if the system presents the player with autonomy, autoaffirmation, competence and relevance in the task to be done [16].

The study considers learning styles as an important element that influences motivation. The learning style of a student is a wide concept that focuses in the particular way that each individual applies to recollect, understand, interpret, organize and think information [18]. There are several models, for example Kolb's model [19], Felder and Silverman's model [20] and the VARK model (Fleming and Mills) [21] that is applied in this research. Designed in 1987 by Fleming, the VARK model categorizes four sensorial modalities of learning style preferences and a fifth category for multimodal students. Students with Visual style process information mainly by sight, they learn by figurative representations, for example graphics, schemes, diagrams and charts. Students with Aural style like to listen or discuss information with others and, to understand better, they opt to listen conferences, tutorials or to record classes to listen to them again in other time. Those who have a Read/Write style prefer to see written words, read text, take notes and read them again to study. Finally, students with a kinesthetic style have a perceptual preference; this means that, in order to learn, they require a connection to reality in the information that they receive. They learn better using simulations or by interacting with reality.

As stated before based on Ryan and Deci [17], learners' experienced autonomy, affirmation, competence and relevance result in autoregulation and autodetermination and work as motivators. These characteristics are needed to undertake learning in a successful way. This study has the objective of establish a relation between gamification, learning, learning styles and motivation assuming that there can be significant differences in motivators related to VARK learning styles.

Gamification, as other emerging learning strategies, possesses few researches that shows experi-

mental data or contrasts methodologies. [22] states that 46.15% of studies are focused on under graduated students as this work does. Among these studies, [22] says that a majority of them applied to education show evaluation methodologies about a gamification implementation but lack of a validation scheme for this activity. Also, [22] found that no document reports the impact of this strategy over the learning gains of students like this work does. Additionally, no studies linking this concept with the learning styles were reported by [22]. The emphasis of gamification studies in the educational context is in the methodological or design aspects that are used in its implementation, such as the incidence of stimuli that are offered and their impact on the results. Among a wide range of stimuli used by these studies are points, levels/stages, badges, leaderboards, prizes, progress bars, storyline, and feedback; but those with higher prevalence in research studies are the first three. Other studies are focused on the difference between their implementation and a more classic implementation of Game Based Learning or the type of players that were observed in the experiment. Examples of these studies are works on [23–25]. Some of them report their experiments only in an anecdotic way from the point of view of the experience lived by the professor or the students or the grades that students presented. Examples of this are the works in the reports [26–29]. Engagement and motivation are a result most frequently reported [13, 22]. This motivation is evaluated by the measurement of the students' access to material or collaboration between students (like in [24, 29, 31]). Other work over gamification and motivation present the theoretical framework that affect students' motivation like [30] or how technology affects motivation like [32]. The work that we present make a contrast between motivation, learning styles and learning gains in a gamification system applied in an under graduated environment.

2. Methodology

The research presented in this document consisted in the application of gamification in two undergraduate classes of the Instituto Tecnológico y de Estudios Superiores de Monterrey campus Ciudad de México. The process was applied to two groups of a Database class for students of the program of Engineering in Computational Technologies. This study was conducted along a whole semester from January to May 2014 during 16 weeks. The number of students that participate was 40 divided in two groups in charge of the same professor. Both groups had 20 students.

The methodology followed by this work was

- Browse the Learning Content Management System (LSM) space for the class before classes start
- Not entering to the LSM space for 5 consecutive days
- Help others to finish a task
- Be the first to finish an exam
- Answer the VARK questionnaire
- Have three homework in a row with a grade over 90 points
- Find mistakes in the professor's material
- All students must arrive in time for five sessions in a row
- Send three mails to the professor asking something from the course
- Be the last one on finishing a homework
- Be the first one on finishing a homework
- Get at least five points, in the second partial grade, over the grade of the first partial
- Get at least ten points, in the second partial grade, over the grade of the first partial
- Have three project task in a row with a grade over 90 points
- Be on the limit of permitted absences
- Have all activities in a partial with a grade over 90 points
- Be late two days on a row
- It's valentines day

Fig. 1. Badges used in the course.

based on a pretest—posttest process and a focus group and a control group was selected. In both groups, the course was designed to have three hours per week inside the classroom, divided into two 90-minutes sessions, and five hours for home study or homework outside class where students worked without the professor. In the focus group, gamification was applied all along the course. The gamification application for this group consisted on the use of 18 badges (Fig. 1) for basic activities in the course as arriving in time a number of classes, improving their grades from partial to partial, being the first student to solve homework, among others. Some of these badges gave points to the students to reach levels in the gamification system. There were 8 levels. Each level was reached by reaching specifics amounts of points. The points could also be obtained with the grades of quizzes applied to students. Some quizzes were only conceptual questions or exercises in paper.

Other quizzes were game like activities (i.e. competitions in teams, guess the word, etc.). If the students reached level 6, they obtained 1/100 point on the final grade. If the students reached level 7, they obtained 2/100 points on the final grade. If the students reached level 8, they obtained 3/100 point on the final grade.

In both groups, professor gave lectures to the students in the two sessions of the week. These lectures were supported by slides and some exercises as examples. At home and individually, students solved homework. This activity was the same (same exercises and weighting) for both groups. The activity was made available at the end of the second session and students must deliver their work before the beginning of the first session of the next week.

3. Results and discussion

In Fig. 2, the partial grades, the final project grades, the final exam grades and the final grades for the focus group and the control group are presented. In Fig. 2, it can be observed that the students' grades for the focus group (gamification group) are relatively constant. On the other side, the grades of the control group (traditional group) present a variation along the semester. All courses in the institution have two partial evaluations and a final evaluation. For both groups, the partial evaluations were a written exam each with duration of one hour and a half while the final evaluation was a written exam with duration of two hours. The first partial evaluation was applied in the week 6; the second partial

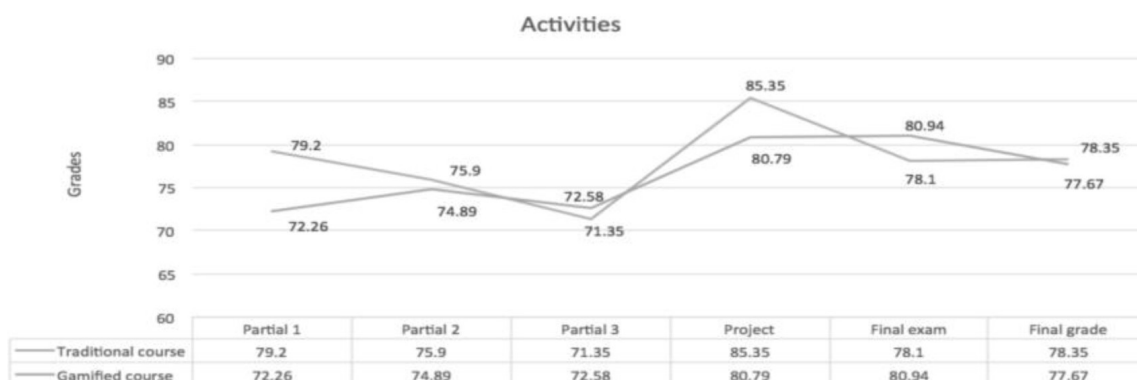


Fig. 2. Partial grades, final project grades, final exam grades and final grades for the focus group and the control group.

Table 1. Weighting for partial grading reports (top) and final grading reports (bottom) for the focus group and the control group

Activity	Percentage
Partial exam	50%
Class activities	10%
Project activities	20%
Homework	20%
Partial grade	100%

Activity	Percentage
First partial	20%
Second partial	30%
Third partial activities	10%
Final exam	20%
Project	20%
Final grade	100%

evaluation was applied in the week 12 and the final evaluation after the week 16, when the classes were over. The exams were not the same for both groups but they were designed with a similar difficulty level. In the same way, students were assigned with a final project. A Project Oriented Learning technique was used for this activity. At the end, students delivered a functional prototype and made a presentation in front of their real clients. For both groups, three grade reports were made: two partial reports and a final report. Partial grades and final grades were conformed as stated by Table 1.

Another way to see the progress of the students is observing their final grades. As an institution policy, the minimal passing grade is 70 points. For the control group, 2 of 20 students failed while, for the focus group, 4 students of 20 students failed. As the number of students who failed in the gamified class is grater it can be observed that the gamification technique affected in some way the students' achievement in the focus group.

In order to have a measure of the learning of the

students other than their grades, a pretest—posttest process was applied. For this research, a questionnaire was designed with 96 true or false questions. The pretest was applied to students the first day of class without any previous preparation. The posttest was applied the last day of class. During these activities students were not allowed to consult any material. Also the questionnaires were solved individually.

For this process, the average learning gain was calculated (Equation 1) and results are showed in Fig. 3. Equation 1 gives a number between 0 and 1 that indicates the percentage that a group have as a learning gain. The equation measures the learning gain of a group face to the average of right answers obtained in the pretest. It can be seen that the gamified class has a greater learning gain than the traditional class.

In order to know more about the process behind these results, we applied the VARK questionnaire to both groups. Also the professor took the questionnaire. Results can be consulted in Fig. 4. First of all, it can be seen that both groups are alike. Only the read/write component in the gamified course is greater than the other. Also, it can be observed that the kinesthetic component is the greatest in both groups this could suggest that, in front of the learning gains showed; a gamified strategy can be useful in this kind of courses.

Also, it can be seen that the focus group has a learning style more similar to that of the professor and that also this group had a greater learning gain. Studies [34–35] state that students that have learning styles similar to that of the professor learn better. In this study, it can be said that this affirmation can be also observed in a gamified learning environment. A deeper analysis can be done while comparing learning styles to grades (Figs 6 and 8) and learning gains (Figs 5 and 7). It can be observed

$$\text{average learning gain} = \frac{\text{posttest} - \text{pretest}}{n - \text{pretest}}$$

Equation 1. Equation to calculate the average learning gains for students in the focus group and in the control group. n is the maximal possible grade for the posttest and pretest activities [33]

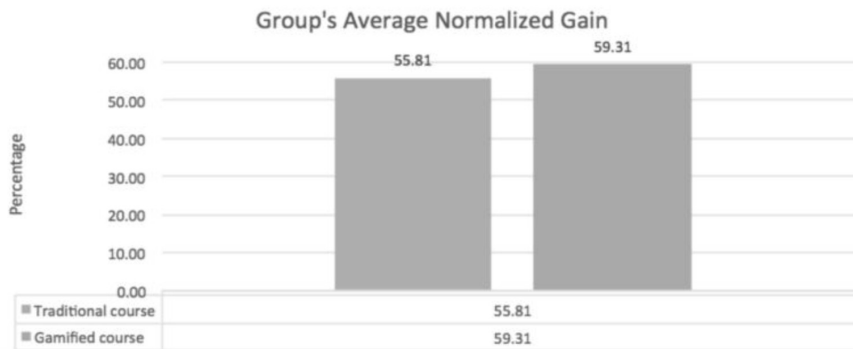


Fig. 3. Learning gains for the focus group and the control group calculated as proposed by Equation 1.

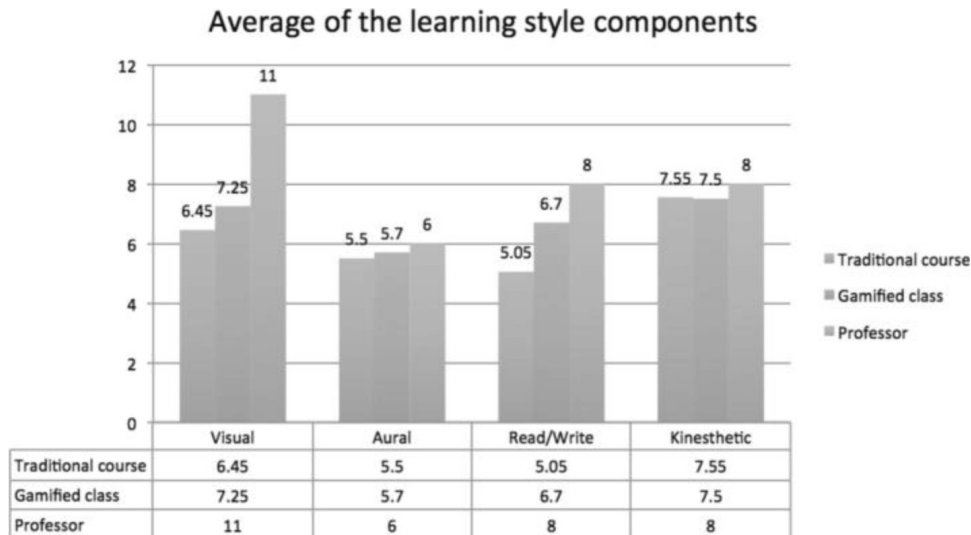


Fig. 4. Professor and groups' VARK questionnaire results.

in the graphs of learning gains (Figs 5 and 7) that learning gains of the control group present greater dispersion than learning gains of the focus group. So gamification gives better support so all students learn more or less in the same amount. Despite this situation, in the graphs of grades (Figs 6 and 8), the inverse situation is showed: grades in the focus group have greater dispersion than those of the control group. This situation can be explained under the light of the theoretical and practical parts of the course.

Because of the nature of the pretest/posttest (true-false questions) the type of learning evaluated in those activities is only theoretical. Final grades were composed of an important amount of partial and whole evaluations over the final project that was developed under a Project Oriented Learning technique so pragmatic knowledge was evaluated. Because of this, it can be said that, the way in which gamification was carried out and its activities to earn points gave better support to the theory learning process (maybe motivating students more) while compromised the practical learning process.

Another important thing to state is that gamification, per se, doesn't support better those students with a multimodal learning style (VARK values in Fig. 5) because a majority of these students are below the average learning gain line. Also, V values in Fig. 5 are above this line maybe pointing that the gamification course strategy may be more useful for these students. On the other hand, it is also noticeable that a majority of kinesthetic students (K values in Fig. 7) in the control group are below the average line, showing that a traditional strategy no longer supports learning in this kind of students. A similar analysis can be done for the grade graphs.

However, in the case of the focus group (Fig. 6), the dispersion is so that no conclusion can be stated from it. But the same situation for kinesthetic students (K values in Fig. 7) can be observed in the control group's graph.

In order to complement these findings, a survey was applied to the students in the focus groups. These questions have four possible options: totally agree, agree, disagree and totally disagree. This survey had the objective of knowing about the motivation present in students to participate in the activities of the gamification system. Results are presented as follow.

Students stated (76% totally agree, 24% agreed) that they participated in the activities because they have satisfaction while learning new things. Students said (71% totally agree, 29% agreed) that they participated in the activities because they are enthusiastic to discover unknown things to them. Students said (94% totally agree, 6% agreed) that they participated in the activities because they'd like to know more about subjects of interest to them. They indicated that (71% totally agree, 29% agree) they participated because they liked to study interesting subjects. These questions show that students took the gamification system as a tool to learn new things or discover things they ignored.

But, in question four, students answered that (59% totally agree, 41% agree) they participated in the activities because they wanted to continue learning about things they've already known. This can be proof that this gamification implementation support better motivation on students when they want to discover new things but it supports less while motivating students to continue learning about things they have known before.

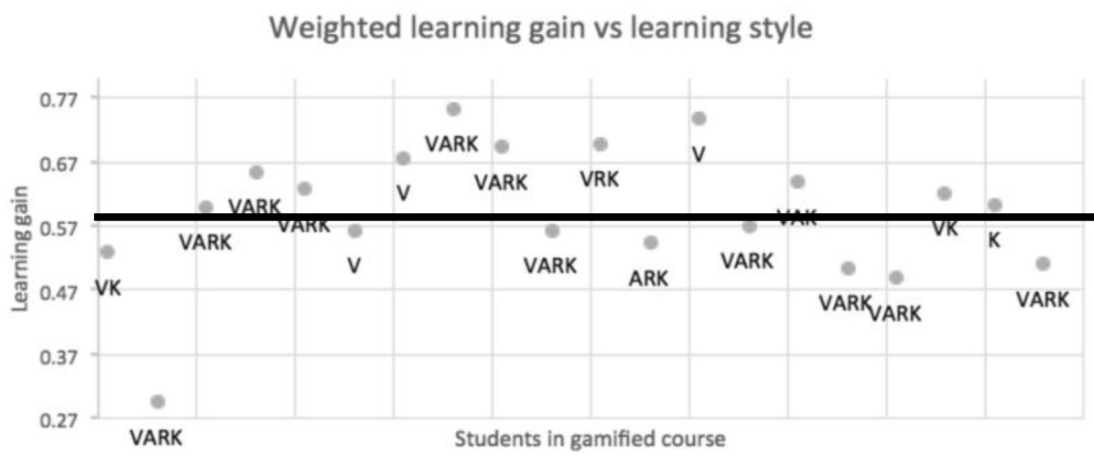


Fig. 5. Learning gains versus learning styles for the focus group. The line is the learning gain average for the group.

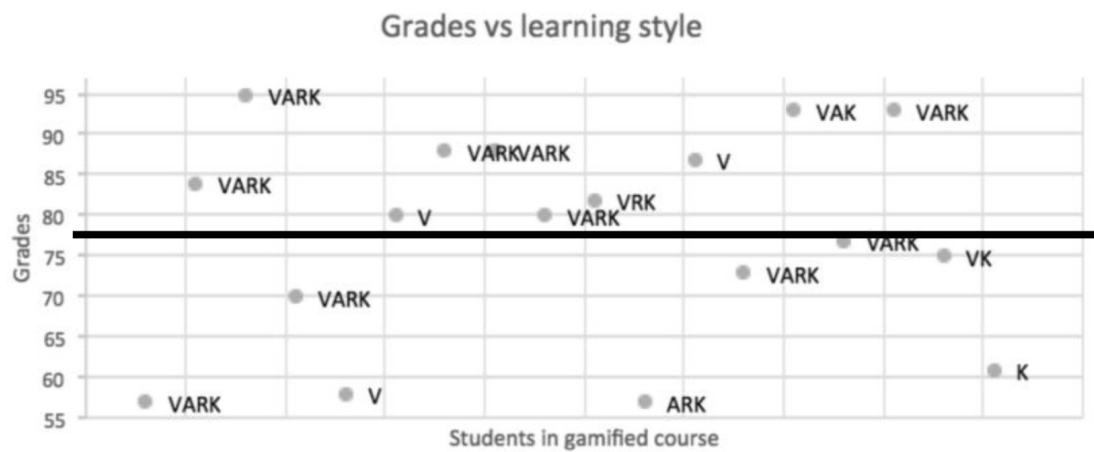


Fig. 6. Grades versus learning styles for the focus group. The line is the grade average for the group.

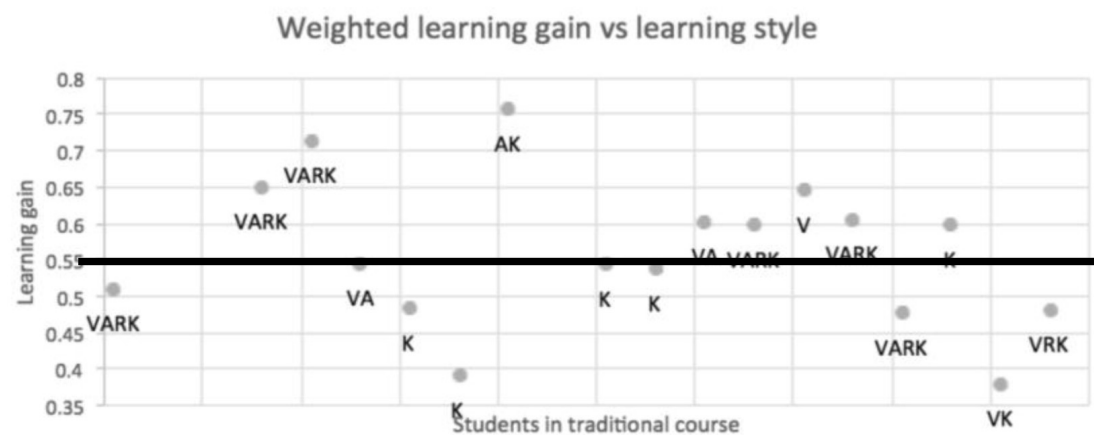


Fig. 7. Learning gains versus learning styles for the control group. The line is the learning gain average for the group.

On the other hand, students answered (82% totally agree, 12% agree, 6% disagree) that they participated because they like to surpass their personal objectives and (76% totally agree, 24% agree) because they felt proud of themselves when

solving hard activities. This helps to say that students found the gamification system as an opportunity to solve challenges and acquire status over other students. But, students stated (41% totally agree, 18% agree, 35% disagree, 6% agree) that they

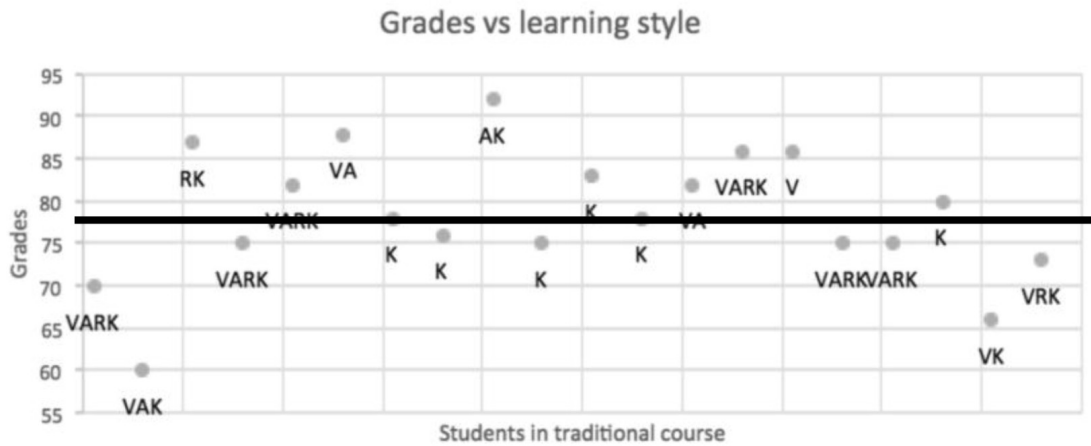


Fig. 8. Grades versus learning styles for the control group. The line is the grade average for the group.

live intense moments when solving additional challenges. This can show that students accept challenge as part of the course but when it comes as an additional activity, motivation decreases in some way. These answers show that students take the gamification activities as an enhancement of their intrinsic motivation because they were motivated by learning new things and surpass challenge and feel proud when doing this.

While asking them about their extrinsic motivation, students answered (6% totally agree, 29% disagree, 65% totally disagree) that they participated because they could not have passed the course or have a better grade without the rewards

in the gamification system. Also, students said that (12% totally agree, 12% agree, 17% disagree, 59% totally disagree) they participated because the professor put it as a requirement in the course. This shows that students hadn't needed the gamification system to boost their intrinsic motivation.

This sample of the answers of the students shows that the gamification system implementation has supported intrinsic motivation of students and that this intrinsic motivation was linked to the learning process inside the course. The answers to the 25 questions in the survey can be consulted in Table 4 (intrinsic motivation), Table 3 (extrinsic motivation) and Table 2 (amotivation).

Table 2. Answers of the students in the focus group to the questions on the motivation survey and its relation to amotivation. The last column shows if students' answers are proof of this motivation supported by the gamification system

I participate in the gamification activities because	Totally agree (%)	Agree (%)	Disagree (%)	Totally disagree (%)	Results are proof of amotivation
Honestly I do not know what is the benefit	18	24	18	41	
I have the impression of wasting time	0	6	41	53	
At the beginning, I felt interested but, after some time, I wasn't sure if I wanted to continue playing	24	24	18	35	
It doesn't matter. I don't need the game in order to learn	0	29	53	18	
It doesn't matter. I don't need the game in order to pass the course	0	35	47	18	

Table 3. Answers of the students in the focus group to the questions on the motivation survey and its relation to extrinsic motivation. The last column shows if students' answers are proof of this motivation supported by the gamification system

I participate in the gamification activities because	Totally agree (%)	Agree (%)	Disagree (%)	Totally disagree (%)	Results are proof of extrinsic motivation
I could fail the course or have a bad grade	6	0	29	65	
The teacher put it as a course requirement	12	12	18	59	
I don't want to disappoint or upset the teacher if I don't participate	12	24	41	24	
I prove that I am able to achieve all challenges	6	29	41	24	
It makes me feel important	6	24	35	35	

Table 4. Answers of the students in the focus group to the questions on the motivation survey and its relation to intrinsic motivation. The last column shows if students' answers are proof of this motivation supported by the gamification system

I participate in the gamification activities because	Totally agree (%)	Agree (%)	Disagree (%)	Totally disagree (%)	Results are proof of intrinsic motivation
I get satisfaction from learning new things	76	24	0	0	✓
I am excited to discover things unknown to me	71	29	0	0	✓
I would like to know more about subjects that interest me	94	6	0	0	✓
It allows me to continue to learn more things that interest me	59	41	0	0	✓
It helps me feel satisfied to be a better student	41	41	18	0	✓
I like reaching my personal goals	82	12	6	0	✓
I am proud to perform difficult activities	76	24	0	0	✓
It gives me personal satisfaction to seek perfection in my abilities	71	24	6	0	✓
I live intense moments when I solve additional challenges	41	18	35	6	
I like to study interesting topics	71	29	0	0	✓
I experience pleasure when I feel completely absorbed by interesting topics	53	24	24	0	✓
I like to feel engaged when I study interesting topics	53	35	12	0	✓
It makes me feel important	6	24	35	35	
I show I am an intelligent person	12	12	35	41	
I prove that I am able to succeed in my studies	18	18	24	41	
I think I'll learn better	12	24	35	29	

As it can be seen, this implementation of a gamification system enhanced students' intrinsic motivation while helping students diminish amotivation and external factors that pushes them to learn. Another important thing that it can be observed is that this implementation fails on motivate students rewarding them with things that affect their grades. This is important because, at the end of the implementation, the professor pointed that rewards that affect students' grades (like points) are dangerous because students that doesn't have a correct learning process are confident that these activities will save them from failing the course. Professor also stated that it is important that the structures in the gamification system avoid stress or confrontation with the structures of the course, like grades or absences limit, so students don't look for bad dynamics along the gamification implementation.

Finally, an open question was applied to both groups where students said what kind of activities they wanted more to have in a class and what aspects must be taken care to offer them a better learning process. In this question, students in both groups said that they wanted more exercises solved in class by the professor but, also, they wanted more game-like challenges throughout the course. Additionally, the students in the focus group said that they liked the way in which the course was carried off and that this methodology helped them to put more attention on the development of the course.

4. Conclusions and future work

In this work, we presented the results obtained in an implementation of a gamification system in two classes of databases for undergraduate students for engineering on computational technologies students programs. This process was analyzed in a pretest-posttest process to know the impact of the methodology over the students' learning gains. Also, the progression in grades of the students was observed.

Although both results show that the focus group had a greater learning gain, values of the two groups are not significantly different. Additionally to the students' characteristics in both groups, this outcome could be also consequence of the teaching style of the professor. It is possible that the professor could have led both groups to a common level of knowledge (this level could also be observed in the final grades). Nonetheless, this study concludes that the gamified strategy helped to diminish the standard deviation on the students' learning gains and the average grades for the focus group. Also, it has been observed that students in the focus group had a better learning process while acquiring theoretical knowledge. This study can be extended to include aspects of competency evaluation so information on practical abilities acquired by students could be analyzed.

Also, under the VARK model for learning styles, results on this study show that visual students are

better supported by the gamification implementation while multimodal students are less supported. It is worthy also say that the traditional methodology applied to the control group had negative implications in the kinesthetic students. This shows the necessity of finding new didactic strategies that complement the traditional didactic techniques to support better the learning process for students that have a large kinesthetic component (like students in this research).

This study also applied a survey about motivation. This survey was composed of 25 questions to analyze intrinsic, extrinsic and amotivation in students. It was observed that the methodology implemented in this study increased intrinsic motivation. Additionally, the types of intrinsic motivation enhanced by the gamification system supported better the learning process for new things and the acquisition of status. Also, it is noticeable that students have a better intrinsic motivation if gamification activities are part of the course; this means that their intrinsic motivation decreases if these activities are additional to those of the course.

In this study, the gamification methodology showed no modification to the extrinsic motivation and amotivation in students. It has been pointed that students stated that they did not need this methodology to earn rewards in order to pass the course. The professor involved in this study also stated that it is important that the structures in the gamification system avoid stress or confrontation with the structures of the course, like grades or absences limit, so students don't look for bad dynamics along the gamification implementation.

This study can be useful to define the first approximations to a more general gamification methodology to be applied to a bigger sample of courses in different domains and analyze its provided learning gains. Although these findings point that traditional methodology and the gamification methodology are somehow equivalent (denying the hypothesis stated), this study concludes that gamification gives better support for millennial students given the results in the focus group and that a complete gamification methodology can emphasize students' intrinsic motivation.

Finally, the results in this work show that the gamification methodology applied gives support to students to develop intrinsic motivation for their learning while making them ignore amotivation and extrinsic motivation factors that could decrease their learning gains. This shows a relative incidence between learning styles, motivation and gamification that can be studied more by implementing a more detailed research about motivation and its influences inside the gamification methodology presented.

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