

# The effect of gamification in 3D virtual learning environments

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## **Abstract**

*This paper focuses on the gamification and social aspects of learning in 3D Virtual Environments and on the evaluation of its effectiveness in the educational process. The gamified learning activity capitalizes on the open source software OpenSim and, through several missions, attempts to create a blended learning environment for the fields of Biology and Computer Science. The gamified learning environment changes the students' behaviour towards the learning process, enhances their self-regulation and establishes more horizontal structure in learning. During the activity, the role of the teacher is predominantly facilitative and assistive, while students, through group learning activities, are fully engaged and become more active learners.*

Keywords: 3D virtual learning environments, gamification, educational activities, missions, self-regulated learning.

## **1. Introduction**

Modern learning theories advocate that effective learning occurs when there is active participation of learners in both individual and social levels. In this study we focus on the exploration of whether modern technologies such as three-dimensional virtual learning environments (3D VLEs) and the collaborative and gamification aspects they offer, can enhance and extrapolate the learning process and if they could suggest more effective teaching methods.

The use of 3D virtual environments (or multi-user virtual environments - MUVES) in learning is well described in the literature (Barab et al. 2012; Tüzün & Özdiñç, 2016; Vrellis et al., 2016). Their difference with typical learning is that the learning process in 3D VLEs is characterized by a high degree of activation and involvement of participants and favors the authentic and collaborative learning. Similarly, game based learning has proven to be an important and valuable way of designing and implementing learning activities (Connolly et al., 2012). Gamification has recently gained the interest of several domains, including learning, as a tool for creating user engagement incentives, enhancing intrinsic motivation and maximizing the benefit from the learning activity. The

creation of intrinsic incentives and increased involvement are linked with self-regulated learning (Pintrich & De Groot, 1990) which in turn is connected with the collaborative and peer-learning (Di Donato, 2013).

This work presents a learning activity established on a virtual world platform and carried out on high school students. The students are voluntarily divided into three groups (Virtual class - VC, Conventional class - CC, Control class/group - CG) and participated in a multi-session activity covering two modules (five sessions on Biology and five sessions on Computer Science). Each virtual class was further divided to five smaller teams, which had to collaborate in order to carry out several missions. Through missions students are motivated to explore the virtual world, collect clues related to the expected learning result and interact with other students and the virtual environment for a long period. The gamification features (Kapp et al., 2014) aimed to activate students, engage them to collaborative learning and improve the learning result.

Brief tests were used before and after each session to evaluate students' performance and one-way ANOVA compared the pre-course and post-course performance. A two-way ANOVA mixed design was used in order to test the relation between the different group formation and the repetitive evaluations. The analysis of results of our main study provided the following findings: The difference in overall performance between the CC and VC is statistically insignificant in both subjects. However, a closer analysis reveals that during the first two sessions, in which the effect of gamification is stronger and the students had intense curiosity and enthusiasm, the difference was significant in favor of the VC. Nevertheless, the repeated use of the same game elements reduced the interest of VC students, so the difference between the two groups returned to the pre test level in which the CC had relatively better performance.

A decision to include similar educational activities in classroom-based courses must consider several issues, such as technical requirements, time and cost effectiveness of designing a virtual course and the usability of the 3D platform. The lack of physical contact, the difficulty of non-verbal communication and the cost of implementing such platforms in education, must also be considered as they can affect the applicability and effectiveness of the activity.

In the following section, an overview of 3D VLEs, game based learning and course gamification are performed. In section 3 we provide details on the design and implementation of the course, with emphasis to the Virtual version. Section 4, contains the details and results of the evaluation, while section 5 summarizes our conclusions from this work.

## **2. Related work**

### **2.1. 3D VLEs and Education**

The educational use of 3D VLEs has evolved over the last twenty years. Soon the affordances of 3D environments were recognized by researchers and educators. The realistic representation of actual situations, the learning ability through the construction of virtual artifacts, the representation of self via personal formed avatars and mainly virtual social gatherings (co-presence)

highlighted a new dynamic way of education (Dede et al., 2004; Dieterle & Clarke, 2007) based on collaborative learning. Within virtual classes, trainees are invited to take an active role, while the instructors plan and coordinate the learning process. During the educational activity instructors intervene only when necessary, allowing learners more freedom to develop new forms of creative expression, to experiment and reach mental schemata in an experiential and collaborative way. Participants via the avatar express their self more freely (Sung et al., 2011), they develop skills, experiment safely, solve problems, understand concepts, interact with the environment and cooperate through role playing (Kamel Boulos, et al., 2007; Ketelhut, et al., 2010).

It is commonly accepted that the educational technologies require careful design so that they can keep learners active. A properly designed educational environment must promote creativity, interaction, collaboration, dialogue and productive debate. Given the rapid development of the 3D multiuser VLEs we perceive that valid documentation of their educational usefulness is required.

## **2.2. 3D VLEs, cooperative, collaborative and peer learning**

Cooperative, collaborative and peer-learning<sup>1</sup> are three forms of learning that can be supported in 3D VLEs (Mennim, 2016). Cooperative learning is more teacher-centered, collaborative is more student-centered and peer learning establishes a more autonomous form of learning which requires greater maturity from trainees who become trainers and vice versa without the teacher's direct intervention (Boud, et al, 1999). Consequently, such a 3D VLE based learning process must be organized in a less teacher-centered manner by placing the students' collaboration at the center, while the teacher designs the training scenario and supports the lesson as a coordinator. The mediators of this virtual interaction are the instructors who undertake different tasks than in a typical classroom (Collins, 1992). They facilitate while handing learning control to learners. The trainees on the other side are invited to play an active role and become more learning autonomous so they can join the modern virtual learning communities of MOOCs, peer-to-peer learning<sup>2</sup> or whatever can be in the future. In self-driven learning models, such as peer-to-peer learning, learners should:

- Undertake more active role in the learning process giving them meaningful choices
- Develop meta-cognitive strategies by “constructing and doing” than watching
- Acquire responsibility giving them the learning process management
- Participate as equal partners in the learning process and engage in collaborative activities

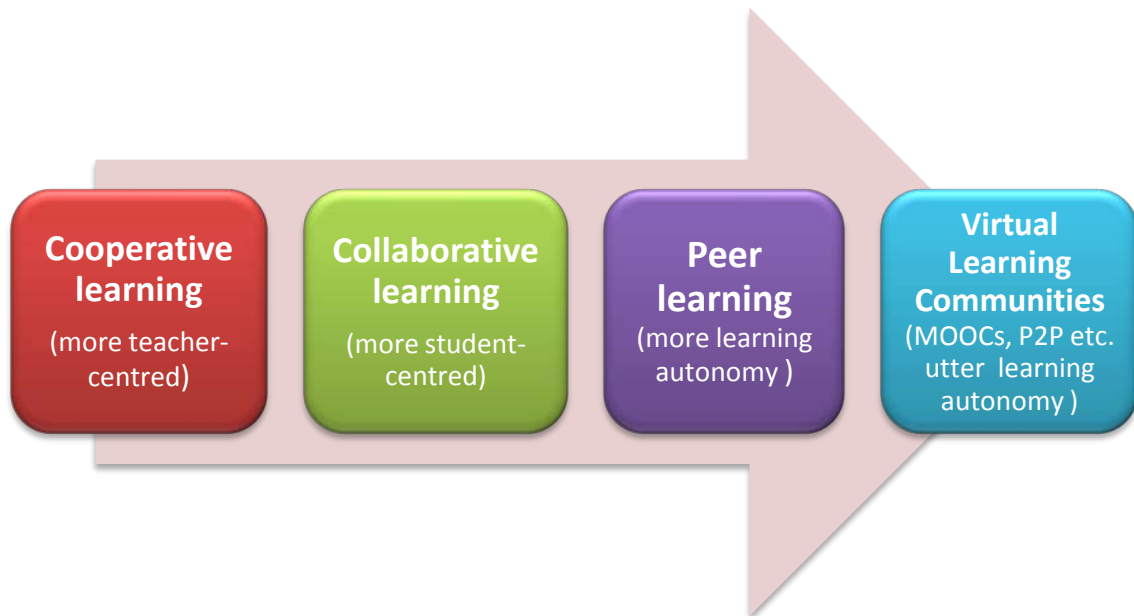
The instructional design of VLEs should consider the individual, interpersonal, and cultural-historical factors separately (Panitz, 1999), so

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<sup>1</sup>The term refers to reciprocal peer learning, which means both peer learning and peer teaching

<sup>2</sup><https://courses.p2pu.org/en/>

students can get involved in the right way in group activities. Figure 1, depicts how the aforementioned learning types lead to self learning in VLCs.



*Figure 1. From cooperative, collaborative and peer learning in the classroom to self-regulated, P2P learning in Virtual Learning Communities.*

Summarizing, the following points must be met in order to encourage collaborative learning and peer-learning in a 3D VLE:

- The student is able to choose or create a representative avatar.
- There should be verbal and non-verbal modes of synchronous and asynchronous communication between participants.
- Students should be complementary and interdependent and work in groups. The completion of the learning activity requires the participation of all and mutual support among members of groups.
- Social skills such as expressing personal opinions, making decisions, understanding of diversity, managing conflicts and disputes etc. should be encouraged and cultivated.
- Each learner should play an active role in the team's success, and all learners must contribute to the team.
- The students' activation must be derived mainly from intrinsic motivation. Thus students take a more active role in the learning process and they become active learning peers which is a peer learning prerequisite. Gamification can contribute in this way.

### **2.3. Game Based Learning in 3D VLEs**

Game Based Learning (GBL) is an instructional proposal aiming to engage students to the active acquisition and management of knowledge (Romero, et al, 2015). GBL is based on learning theory of constructivism and social constructivism. According to these theories cognitive development is achieved when students participate in learning environments that allow them to build their knowledge both through internal cognitive conflicts and through interaction with others. Through the digital game learners experience the freedom to

experiment, to pretend roles, to repeat their efforts without fear of failure, to socialize and ultimately to build knowledge. Through repetitive procedures, tests and experiments, as well as immediate feedback and rewards players can improve their self as suggested by theories of self-regulated learning (Giabbanelli, & Crutzen, 2015). Within a collaborative playful environment the students can exchange views, and support each other in every learning activity (Kavitha & Ahmed, 2013).

#### **2.4. Content Gamification in 3D VLEs**

Gamification is the use of game elements and digital game design techniques in non-game contexts and is divided to structural and content gamification (Kapp, et al, 2014). Structural gamification refers to the implementation of game elements that activate students to use the learning content, without changing the content itself. In content gamification the implementation of game elements and game mechanics changes the content which becomes 'more' playful. For example, adding an imaginary scenario in a course, putting a challenge in the beginning instead of a list of hypothetical cognitive goals.

The key elements of digital games coincide with content gamification and comprise: a) scenario, b) challenge, c) curiosity, d) character, e) interaction, f) feedback, g) the possibility of failure. All these features are used in combination with the ability to choose among the available activities (according to Self Determination Theory) those that make sense, are pleasant and provide a sense of self determination (Ryan & Deci, 2000). According to this theory, the elements required to enhance the inherent engagement and activation are. a) the *competence* response to stimuli in the external environment (manufacturing, learning, communication skills, etc.), b) the *relatedness*, i.e. the innate need for connection and interaction with others and thus the acceptance of social norms and rules, c) the *autonomy*, the innate need for self-control of life. These three elements are related to intrinsic motivation and self-regulation learning and they were taken into account when we designed gamified learning activities for this study.

Rewards are a feature of the learning environment that should be used with caution (Conway, 2014). Applying just only rewards in educational technology such as points badges and leader boards, is possible to reduce the performance of learners (Hanus & Fox, 2015). Digital games do not only focus on rewards, but provide motivation because of their effect on cognitive, emotional and social levels. Thus gamified learning processes should take into account these factors (Lee & Hammer, 2011). The advantages of 3D VLE within gamified learning are based on the use of the 3D graphical environment, the digital construction ability, the interaction, the sense of presence and co-presence, the sense of cooperation, the immediate feedback, etc., which can make gamified learning in 3D VLEs quite effective (Hanus & Fox, 2015).

The present implementation for this study is a combination of a digital game, a simulation, and an implementation of content gamification. It is not purely a digital game because there is no an absolutely fantastic condition, the involved students have the sense of their class and through their avatar, represent

themselves in the environment. It is not a simulation because there is a story that gives meaning to the content of the subject. Finally it is not a conventional system of gamification because it has a three-dimensional graphical interface and game mechanics influenced by MMORPG game.

### **3. Methodology**

#### **3.1. Experimental design**

The design was quasi-experimental because the participants joined in the experimental groups voluntarily and not randomly. This design was necessary for the study that entailed game elements as a way of learning. Participants must be able to choose their way of learning and thus join the respective class voluntarily in order to satisfy the criterion of freedom of choice which is an intrinsic component of play. In the bottom line students who were more accustomed to computers and specifically digital games have chosen to join the Virtual Class (VC), whereas the remaining students joined the Conventional Class (CC). An additional control group (CG), was formed, comprising students with the same characteristics (gender, age, etc.) to the members of the two other groups and similar average performance.

The difference between the conventional learning and gamified learning was investigate for both subjects of Biology and Computer Science. A total of 51 students of the Secondary School<sup>3</sup> were divided into two experimental groups and one control group:

- Control Group (CG, N = 10).
- Conventional Class (CC, N = 22 in Biology, N = 19 in Computer Science)
- Virtual Class (VC, N = 19)

The CC was taught the subjects in the conventional manner (in class presentations by the teacher, questions, etc). The VC completed the modules in the digital environment, it was given explanatory notes and participated in gamified learning activities. The CG answered the assessment questions without having learned anything in order to be a reference point for the learning outcome.

#### **3.2. Research questions and hypothesis testing**

The main hypothesis that this study tests is the following:

*Do VCs improve the learning performance through the digital game within the virtual environment compared to CC?*

Additional research questions have been examined, such as whether the VC group has more homogeneity in performance from the CC, whether the environment operates more efficiently to students on lower performance and whether the students of the VC perform better for each of ten sessions

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<sup>3</sup>The high school of Kanalaki Preveza, a small village in Northern Greece, was the school of study.

compared to the students of the CC. Finally, we asked students to evaluate the degree of satisfaction from the various game elements and game mechanics and the seven basic features of content gamification.

### **3.3. The design of gamified learning activity**

The 3D VLE engine was installed on a local server, and 10 desktop clients were used for implementing the blended learning structure as described in our previous work (Konstantinou et al, 2009). A lot of open access 3D objects and scripts for Opensimulator<sup>4</sup> were used to create the environment and emphasis was given to the design of the gamified activities, which took into account several factors from the self determination theory. The gamified activities: a) allowed participants to compete, taking into account their level of ability and developing strong beliefs of competence (competence), b) allowed the relationship between the participants, through interaction, collaboration and socio-cognitive agreements and disagreements (relatedness), c) provided the feeling of freedom of choice (regarding objectives, browsing, objects, avatar, etc.) (autonomy).

During the game (see Figure 2), students were free to navigate to the world, play together, test communication channels, create test objects and shape their avatars, in an effort to strengthen the belief of competence, the spirit of collaboration and the personal expression of each student. A three hours practice course preceded the educational game in order to let users familiarize with the platform. This is the minimum time for familiarization, whereas up to 40 hours of training may be necessary for acquiring advanced skills.

In LEVEL 1 all the students are in the same virtual space. At this level, for the subject of Biology, students enter a 3D castle and navigate in order to gather information regarding the operation of the senses (touch, vision and hearing), which will be necessary for the following levels. In LEVEL 2 each group of students 'teleports' to a different island (called 'sim'), which is the fundamental piece of space in the virtual world. All five islands are identical but are not accessible to members of other groups. In this level, the players have to help the residents of the city that have been hit by an unknown virus, using the knowledge acquired in LEVEL 1 concerning the operation of senses.

By answering to residents' (agents-bots) questions, auxiliary characters appear that give digital objects to players. These objects are collected and help them to get the coordinates for the next level. The two avatars of each color group must co-operate in order to accomplish the mission as fast as possible. For the first two levels, students spent five teaching hours that correspond to the credit hours required to complete this chapter in the course of Biology.

In LEVEL 3, students from all groups gather again in the main "island". The completion of this level signals the end of the first part of the game and declares a winner team for this part. However, in order to proceed to the next level, all

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<sup>4</sup>Oar files AutumnCastle.tgz , ZadarooEnglishGarden.tgz, were used which are available under Public Domain license and downloaded from <http://zadaroo.com/>. File gianttree.oar and hax nuit.oar are under CC BY 3.0 license from <http://enerhax.com>

the teams must complete the mission and deliver their virtual objects to the agent-bot, in order to get the coordinates for the next level. So the teams that have completed the mission assist all other teams to finish their activity.

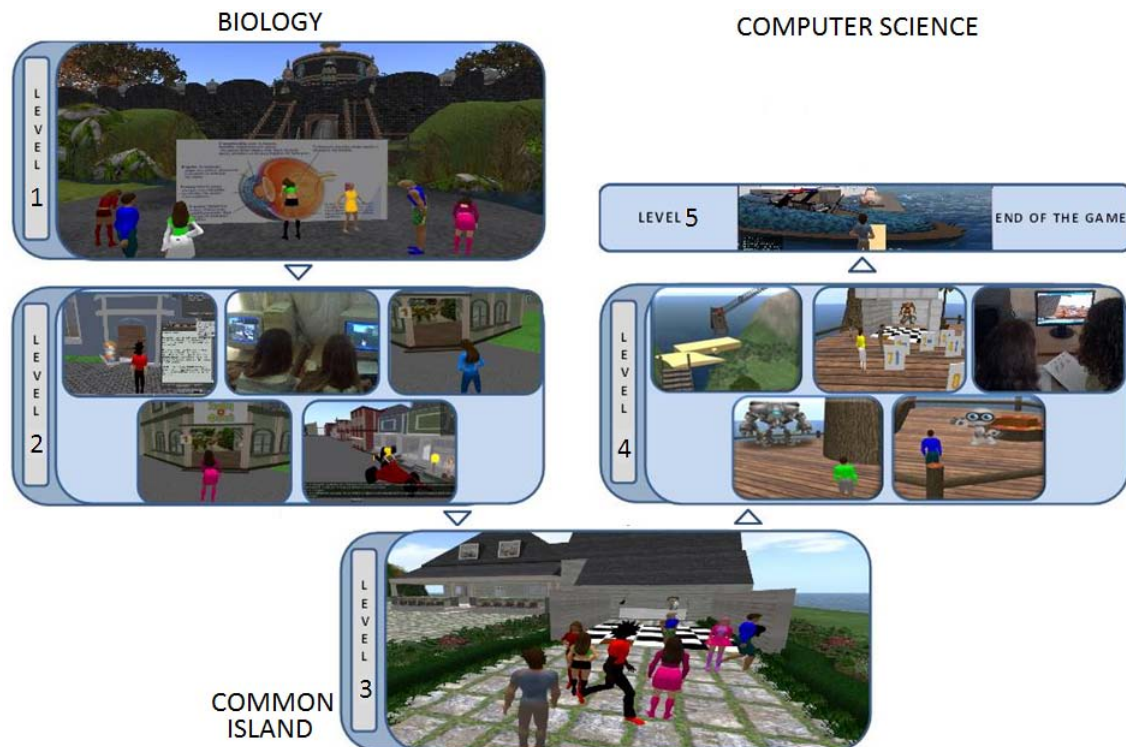


Figure 2. The gamified activities in all levels

In LEVEL 4, teams move to separate islands again and acquire knowledge on Computer Science and Algorithms. After completing the level's mission they can obtain the "key" to find the fifth and final island. In LEVEL 5 they have to find the "big boss" of the island and answer correctly the two questions of logic that he asks in order to win the game.

Learning activities were designed taking into account elements of peer and self-regulated learning. Throughout the gamified learning process, the role of the teacher was just supportive. Students could study the subject by themselves, at their own availability and as many times as they wanted (of course against the time). There was an attempt to make students more learning autonomous and more collaborative by completing their missions and providing assistance to each other whenever was necessary.

#### 4. Evaluation

At the begging of the study we made all the necessary test of normality and equality. The Shapiro-Wilk test of normality validated that the performance of all students follows the normal distribution. A t-test for equality validated that both CC and VC are statistically equal regarding the general average performance.

##### 4.1. Evaluation of the Biology sessions

Before and after each of the five biology sessions, the three groups had an assessment, comprising questions of equal difficulty regarding the taught module. Members of the VC and CC groups have attended a brief, conventional



course presentation. Afterwards, the CC students were given a detailed presentation, comprising more details and slides, and a discussion on the topic, whereas the VC students joined the virtual world for the game. CG students answered the questions based only on their previous experience and knowledge, without being taught any of the concepts involved.

Table 1 displays the descriptive statistics of the students' post-course performance (top) and the analysis of variance (ANOVA) for each group (middle) for the five Biology sessions. Comparison of the three groups (Table 1, bottom) shows that the performance of the CG is particularly low in the post test evaluation. The learning outcome in VC is improved compared to their pre-course performance by 30%, while CC appears to have a comparative improvement (see Figure 3). Regarding the standard deviation of performance within the same group, there is a slight improvement in the homogeneity of VC members' performance (17.32) against that of CC members (18.91), which indicates the improvement of the weaker students cognitive performance

Table 1. Comparisons of average performance of the three groups in Biology.

**Post course/activity performance**

|       | N  | Mean   | Std. Deviation | Std. Error | 95% Confidence Interval for Mean |             | Minimum | Maximum |
|-------|----|--------|----------------|------------|----------------------------------|-------------|---------|---------|
|       |    |        |                |            | Lower Bound                      | Upper Bound |         |         |
| CG    | 10 | 13.393 | 7.383          | 2.335      | 8.111                            | 18.675      | 5.00    | 31.07   |
| CC    | 22 | 64.075 | 18.911         | 4.032      | 55.690                           | 72.459      | 25.36   | 92.14   |
| VC    | 19 | 65.461 | 17.328         | 3.975      | 57.110                           | 73.813      | 32.86   | 100.00  |
| Total | 51 | 54.654 | 26.306         | 3.684      | 47.255                           | 62.052      | 5.00    | 100.00  |

**Analysis of variance (ANOVA)**

|                | Sum of Squares | df | Mean Square | F      | Sig. |
|----------------|----------------|----|-------------|--------|------|
| Between Groups | 21196.355      | 2  | 10598.178   | 37.950 | .000 |
| Within Groups  | 13404.937      | 48 | 279.270     |        |      |
| Total          | 34601.293      | 50 |             |        |      |

**Multiple Comparisons Dependent Variable (Tukey HSD)**

| (I) GROUP | (J) GROUP | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval |             |
|-----------|-----------|-----------------------|------------|------|-------------------------|-------------|
|           |           |                       |            |      | Lower Bound             | Upper Bound |
| CG        | CC        | -50.682               | 6.373      | .000 | -66.096                 | -35.268     |
|           | VC        | -52.068               | 6.529      | .000 | -67.858                 | -36.278     |
| CC        | CG        | 50.682                | 6.373      | .000 | 35.268                  | 66.096      |
|           | VC        | -1.386                | 5.234      | .962 | -14.044                 | 11.272      |
| VC        | CG        | 52.068                | 6.529      | .000 | 36.278                  | 67.858      |
|           | CC        | 1.386                 | 5.234      | .962 | -11.271                 | 14.044      |

\*. The mean difference is significant at the 0.05 level.

A deeper analysis of the performance for each teaching session reveals that in the first two sessions the VC group outperforms the CC one, but after the third session the VC performance is decreasing. Since the difficulty of questions is stable over the sessions, this drop in performance of the VC group is possibly related to the drop in excitement as depicted in Figure 4. The excitement of VC members was evaluated using a Likert scale and its positive correlation with performance is obvious. Based on what VC students stated in personal

interviews after the course completion, the number of the questions and the repetition of questions in case of error was boring and reduced their initial enthusiasm, it distracted their attention and lead to "mechanical" responses and reduced performance.

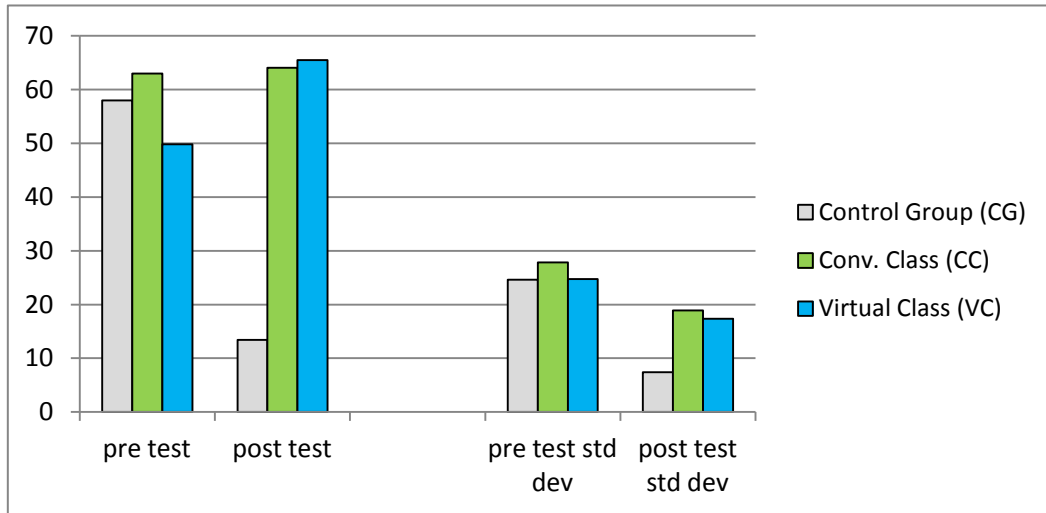


Figure 3. The post-course performance of the three groups.

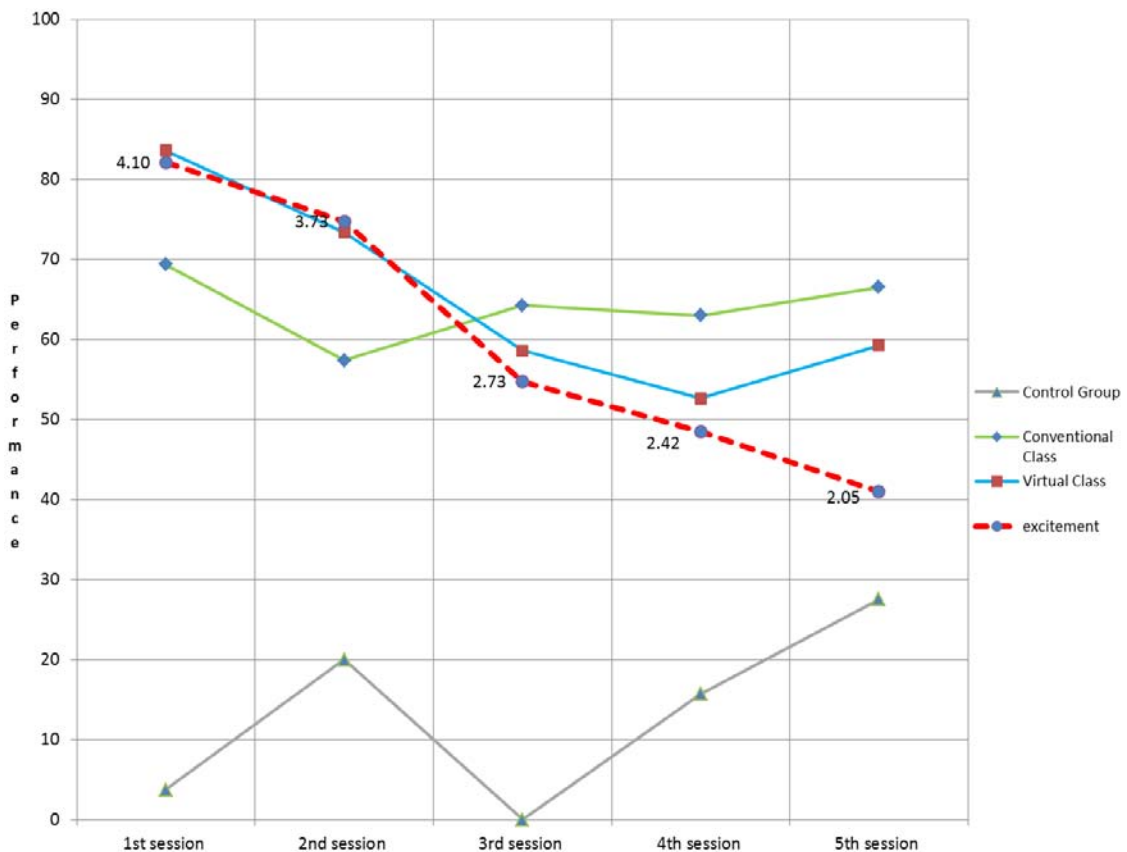


Figure 4. Analysis of students' performance and excitement (for the VC only) by session

Using a two way ANOVA, with the experimental groups (CC and VC) being factor A and the five sessions being factor B, we found a statistically significant relation ( $F_{A \times B} = 10,015$ ,  $p = 0,000$ ,  $\eta^2 = 0,20$ ), as well as the main effect of factor B ( $F_A = 12,52$ ,  $p = 0,000$ ,  $\eta^2 = 0,24$ ), while the main effect of factor A is not statistically significant ( $F_B = 0,059$ ,  $p = 0,809$ ,  $\eta^2 = 0,002$ ). This indicates that the difference in performance between members of CC and VC is statistically significantly. Also, the effect of the group factor (CC or VC) is different in each of the five sessions. The statistically not significant main effect of factor A means that the null hypothesis regarding factor A is accepted. There is no effect in the learning outcome that is only dependent on the experimental groups. However between five teaching sessions there are significant differences.

#### 4.2. Evaluation in Computer Science sessions

During the computer science session students of the three groups are requested to answer questions on variables and algorithmic structures. The control group answered the questions using only previous knowledge, the members of the CC group were taught using conventional presentations and additional reading material, whereas the members of the VC group had an introductory presentation for one hour and then joined the virtual world. They also had at their disposal the same reading material as the CCs' students.

Table 2 displays the statistics concerning the performance of the three groups in the pre and post course evaluation tests.

Table 2. Comparisons of average performance of the three groups in Computer Science.

##### Post course/activity performance

|       | N  | Mean   | Std. Deviation | Std. Error | 95% Confidence Interval for Mean |             | Minimum | Maximum |
|-------|----|--------|----------------|------------|----------------------------------|-------------|---------|---------|
|       |    |        |                |            | Lower Bound                      | Upper Bound |         |         |
| CG    | 10 | 9.800  | 9.102          | 2.8787     | 3.289                            | 16.311      | .00     | 24.00   |
| CC    | 19 | 41.790 | 27.067         | 6.20970    | 28.743                           | 54.836      | 12.50   | 100.00  |
| VC    | 19 | 48.105 | 26.598         | 6.102      | 35.286                           | 60.925      | 22.00   | 94.00   |
| Total | 48 | 37.625 | 27.992         | 4.040      | 29.497                           | 45.753      | .00     | 100.00  |

##### Analysis of variance (ANOVA)

|                | Sum of Squares | df | Mean Square | F     | Sig. |
|----------------|----------------|----|-------------|-------|------|
| Between Groups | 10158.703      | 2  | 5079.351    | 8.571 | .001 |
| Within Groups  | 26667.047      | 45 | 592.601     |       |      |
| Total          | 36825.750      | 47 |             |       |      |

##### Multiple Comparisons Dependent Variable (Tukey HSD)

| (I) group | (J) group | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval |             |
|-----------|-----------|-----------------------|------------|------|-------------------------|-------------|
|           |           |                       |            |      | Lower Bound             | Upper Bound |
| CG        | CC        | -31.990*              | 9.511      | .004 | -55.039                 | -8.940      |
|           | VC        | -38.305*              | 9.511      | .001 | -61.355                 | -15.256     |
| CC        | CG        | 31.989*               | 9.511      | .004 | 8.940                   | 55.039      |
|           | VC        | -6.316                | 7.898      | .705 | -25.458                 | 12.826      |
| VC        | CG        | 38.306*               | 9.511      | .001 | 15.256                  | 61.355      |
|           | CC        | 6.316                 | 7.898      | .705 | -12.826                 | 25.458      |

\*. The mean difference is significant at the 0.05 level.

The difference between CG and two experimental groups is statistically significant as expected. Also between the CC and VC is a difference of 6.32 points, which is not statistically significant, however, is an indication of improving the learning outcome in favor of VC. The comparison of performance in the pre-course and post-course tests is depicted in Figure 4. The post-course test comprised harder questions and this resulted to an overall decreased performance for all groups.

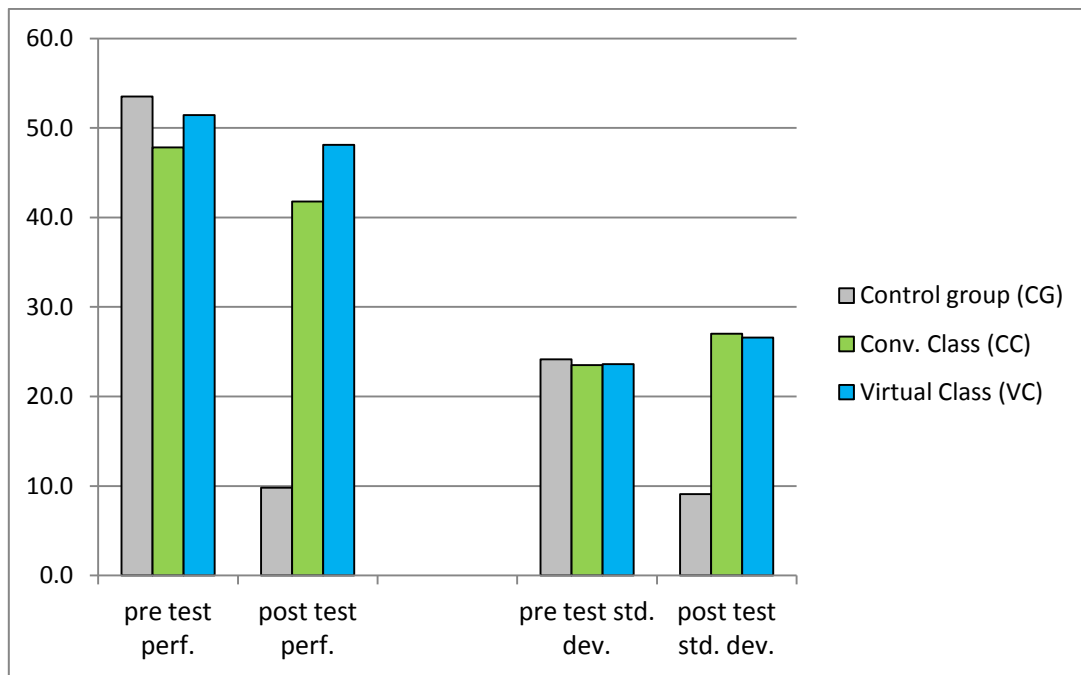


Figure 4. Comparative performance of the three groups in Computer Science.

The same two-way ANOVA as in Biology sessions was performed for Computer Science sessions. The result of the interaction between the variables is not statistically significant ( $F_{A \times B} = 0,993$ ,  $p = 0,387$ ,  $\eta^2 = 0,027$ ). The main effect of the factor B (sessions) ( $F_A = 60,974$ ,  $p = 0,000$ ,  $\eta^2 = 0,62$ ) is statistically significant, while the factor A (experimental groups CC and VC) was not statistically significant ( $F_B = 0,526$ ,  $p = 0,473$ ,  $\eta^2 = 0,014$ ). The statistically non-significant interaction between the factors A and B, means that the performance between participants in five sessions was statistically insignificant between CC and VC. So the effect of the group factor is similar across the five sessions. However, there is a small percentage improvement in favor of VC mainly for the sessions 2, 3 and 4. The main effect of the factor A (group) is statistically not significant. This means that there is no effect in total learning outcome which depends only on the group which the student belongs. However, the main effect of factor B (session) indicates that there is great variation in student performance for both groups, which is associated with the factor B (the content and the assessment of each session).

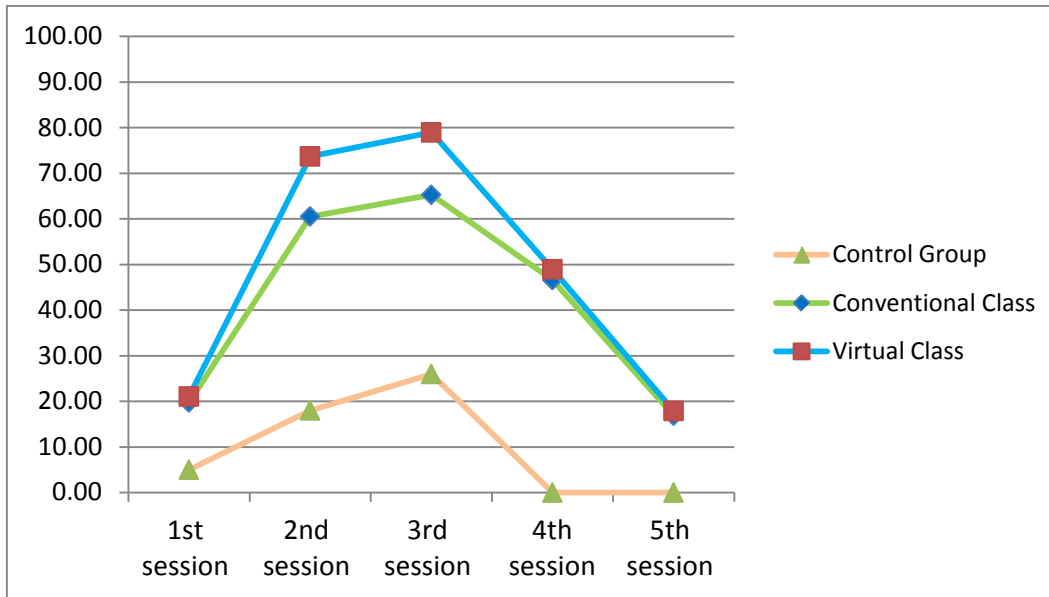


Figure 5. Average performance of students in the Computer Science sessions.

This variation mainly relates to the 1st and the 5th session. Students of both groups struggled to answer questions based on *schematic* type programming knowledge (Coull & Duncan, 2011). However in the 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> session that cover knowledge on *syntactic* type programming, performance improved for both groups. Although it was statistically insignificant the VC's performance was increased in the 2<sup>nd</sup> and 3<sup>rd</sup> session by 17.8% and 16% comparing to CC.

## 5. Conclusions

The results of the current study are in agreement to previous studies, especially in what refers to the learning result which is in favor of the virtual environment. However, in this study, we exploit in tandem the virtual worlds' technology, content gamification and digital game features within the learning environment. The topics covered are from the fields of Biology and Computer Science and follow the specific secondary education curriculum.

The performance of the virtual class in Biology is significantly better than the control class but comparable to the conventional class. However, there is significant improvement to the worst performance of the VC between the pre and post course tests. This shows that the motivation for collaboration reduces the differences between the class members and increases homogeneity. Similar conclusions are drawn for the Computer Science sessions where VC performance is better by 6.32 points but still not significantly better than that of CC. Comparison across topics reveals differences between Biology, which mostly requires declarative knowledge (mostly recognition of concepts), and Computer Science which comprises both declarative and procedural knowledge. All groups found it hard to answer procedural questions that require in deep knowledge and advanced analytic and synthetic skill.

In conclusion, the gamified activity in the 3D VLE temporarily increases the excitement of students and increases their engagement. It also increases their competitiveness and their interest to answer correctly, but also to collaborate and support other teams in order to move forward with the mission. The aim of this gamified learning process was not only knowledge per se, but also to motivate participants to search for knowledge in multiple sources, in content provided by the tutor, on the internet or even in their class mates. This model of learning can support the intrinsic curiosity of students for anything new and help them remain active and always evolving learners.

The next steps of our work are to improve the game elements and game mechanics based on the results of the current study. Further research is needed after implementing a full distance learning course without the physical presence of a tutor in the class in order to evaluate a more self-regulated learning process. .

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