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A Teaching Method Based on Virtual Worlds and Mastery Learning

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Abstract

The evolution of virtual worlds in education has provided the creation of new pedagogical alternatives. In the present study, we explore this potential, integrating the Bloom's Mastery Learning theory, designing a teaching method based on periodical assessments, and supplementary, support offered through the use of an OpenSim virtual world. An experiment was carried out during half of the school year of 2017, involving 74 sixth grade students in a Science class, divided in control and experimental groups. The results demonstrated better performance of the group using the virtual world in comparison to the group using the Moodle learning platform, in which, the post-test presented a slightly higher median for Group 2 (84.50) compared to Group 1 (83.00). As for the student's impressions, it was in general of acceptance and positive impressions about the experience.

1.   Introduction

Information and Communication Technologies (ICT) have enabled new possibilities for the use of computational resources as an element of support in the teaching and learning process. Among them, it is the growing technological evolution of three-dimensional (3D) environments, also known as virtual worlds or Metaverses. Bainbridge (2010) defines virtual worlds as persistent online environments generated by computers, where people can interact, either for work or leisure, in a manner comparable to the real world.

Virtual worlds bring the unique characteristics of immersion and high interactivity, which increases user attention. In this way, they can complement with the students' didactic material either in the classroom or at home by computer-based activities, and thus, they are a propitious space for the application of different learning theories. For example, studies like those of Devlin et al. (2013) and Sajjanhar & Faulkner (2014) have correlated concepts of Kolb's Experimental Learning (1984) in an attempt to represent the four steps of a proposed cycle of didactic activities carried out in a virtual world.

In addition, different educational areas and subjects can also be contemplated in virtual worlds. Winkelmann et al. (2017), for example, addressed Chemistry, in which simulations of 3D molecule structures, solutions, and chemical reactions were created. Jacobson, Taylor, and Richards (2016), by the turn, explored the teaching of Science, targeting the accomplishment of tasks in a more ludic manner.

This study proposes the integration of virtual worlds with the Mastery Learning (ML) educational theory, towards the teaching of Science. The ML theory is advocated by Benjamin Bloom (1968) and assumes that more than 90% of learners can achieve learning objectives at the same mastery level if they are provided with adequate learning conditions. Such adequate conditions, nowadays, are permeated by the use of ICT resources. For this reason, the present study has adopted virtual worlds as ICT to complement the activities carried out in the classroom.

The ML method is based on the division of a topic into modules, with predetermined objectives for each module and a framework devised to plan sequences of instructions, so that all the students can reach a reasonable performance level in a given topic (Marteleira, 2010). Students who demonstrate difficulty in achieving the required success level to move forward have to receive remedial activities through tutorials, discussions and supplementary materials. The method has proven to be effective in a wide variety of areas, such as in Chemistry (Mitee & Obaitan, 2015) and Science (Agboghorom, 2014).

The research problem of this study was centered on how to devise an approach that would rescue the main points and benefits of the Mastery Learning educational theory, which, despite having already been widely used in previous decades, is still criticized because it is characterized as an approach considered too instructional and sequential. This issue has been discussed already in the works of Marteleira (2010), López (2006), and Guskey (2010). To this point, its aggregation to Information and Communication Technologies has been seen as an exciting alternative to be adopted, especially in what concerns to ally its educational methodological structure with the accomplishment of didactic activities, that involve innovative resources, such as virtual and augmented reality, among others. This point presents a loophole to create new alternatives for the use of Mastery Learning combined with the use of new technological resources, motivating the creation of new teaching proposals.

Based on this, the objective of this study is to tackle the exciting challenge of devising, step by step, a teaching method for formal education focused on assisting the students' Science learning process, by integrating the Mastery Learning theory with the use of virtual worlds. Science learning

is a very abstract subject and is known to be difficult. It is even a greater obstacle for children in the formal operational stage (adolescence to adulthood) (Piaget, 1976). That is why it requires the use of laboratories to perform practical experiments. However, a science lab is not always available for use in public schools, as they have an inherently high cost of maintenance.

The article is structured as follows: Section 2 presents the related studies, Section 3 addresses virtual worlds in Education, Section 4 focuses on the Mastery Learning theory, Section 5 presents the research method, Section 6 delivers the results, ending in Section 7 with the conclusions.

2.   Related Studies

Virtual worlds have been applied as educational support in a diversity of areas, such as in Health (Sgobbi, Tarouco, and Reategui, 2017), Foreign Language Learning (Hsiao, Lan, Kao and Li, 2017), Chemistry (Winkelmann, Keeney-Kennicutt, Fowler, and Macik, 2017), and Science (Jacobson, Taylor, and Richards, 2016). In the scope of Science teaching, virtual worlds have proven an alternative feasible to be implemented, with the possibility of creating scientific experiments in this scope.

The last decades marked the recapture of the Mastery Learning theory, being this statement confirmed by Guskey (2010), motivated in large part by the technological evolution brought about with the use of ICT and computer access in schools, thus creating new and better conditions to implement this approach. The research carried out seems to vary in terms of target population (from elementary to university students) and educational technologies to support the activities, but there seems to exist a scarcity of studies involving the use of virtual worlds.

In this way, the choice for these two areas (virtual worlds and Mastery Learning), considered interdisciplinary and highly flexible in their mode of application, are justified for the development of a method that is not anchored to a specific educational area, therefore allowing different researchers and teachers to explore this approach in its several areas of application. The present study stands out in proposing the integration of an educational theory widely known in the academic milieu with a technological trend for modern education - the virtual worlds.

It is important to emphasize that the tests of this research were carried out in the area of Sciences; however, this type of emphasis does not limit the validity of the proposed method to be implemented in other areas of application.

3.   Virtual Worlds in Education

Chow (2016) explains that in a 3D virtual environment, students are free to explore it, where learning becomes more active and participatory rather than centralized in listening and absorbing information. This thinking is also shared by Simsek and Can (2016), who assert that giving students the freedom to choose the type of learning material they want to explore makes them active individuals, thereby experiencing the feeling of authorship during the process. The diversity of resources such as text or voice chats, the possibility of freely browsing the scenarios, and autonomously interacting with elements in the virtual world can offer a favorable environment for this change of attitude.

Despite these benefits, virtual worlds have different types of limitations in their mode of application – several of them are demonstrated by this study's experiment. Problems involving the difficulties in accessing the virtual environment due to a bad Internet connection or limited hardware resources are the most significant obstacles (Young, 2010). The lack of support for access from mobile devices can also be considered as one of the main obstacles currently addressed in studies concerning virtual worlds.

The possibility of building laboratories in virtual worlds arises as an exciting alternative to be explored, which induced the choice of the Science area as the school subject for this purpose. Traditionally, this subject is characterized by the use of physical laboratories, which help in the conduction of experiments viewed solely from a theoretical perspective in the classroom. Maiato (2013) explains that teachers reinforce the tendency to view the subject as a stimulating and engaging by taking their students to the school's science lab to practical classes, motivating student participation and consequently fostering learning.

For Burbules (2010), immersive learning environments do not distinguish between action, reflection, and questioning, since the student learns through the presentation of concepts and theory; through the simulations, inherent in these environments, they experience the practice, and through the tools of communication – questions. According to Girvan and Savage (2010), the main aspects that contribute to the immersion of the user in 3D environments are the interaction and communication possibilities. In education, these tools are pillars of constructivist learning, thus contributing meaning to knowledge.

4.   Mastery Learning

The interaction established in virtual worlds generally attracts students' interest and enthusiasm. However, it should be noted that these environments cannot effectively replace all other existing learning approaches (Zaharias, Andreou, & Vosinakis, 2010). Furthermore, the didactic planning carried out by the teacher, based on a well-defined educational approach, is necessary to guide the objectives of the activities and help students perform their tasks more adequately and consistently in the virtual environment.

This aspect was specially considered in this study, which assumed that merely using a virtual world would not be sufficient, calling for the need to establish an adequate didactic planning, which, for this particular case, drew on the educational theory of Mastery Learning.

In Mastery Learning, the lesson topics are divided into small modules ordered by a logical sequence, with predetermined specific objectives to follow until they are reached. During this process, students can work alone or in groups within each lesson block in a series of sequential steps, where they must demonstrate a high level of success before moving on to new lessons (Marteleira, 2010). At the end of each module, an evaluative test is applied to measure whether the student achieved the success intended, that is, if they hold the necessary knowledge to proceed to the next module, or whether remedial activities must be offered.

In this sense, students who do not reach the required level of mastery receive immediate feedback followed by remedial activities, while others can be led to enrichment activities. It is, therefore, recommended that the didactic materials and remedial activities for students below the required level, will be different from those used in the regular class, as these were not enough to push the student forward, or perhaps, the previous materials need to be updated to provide better results. After the abovementioned corrective actions, a new formative test must be applied in order to measure the progress of the student. In turn, enrichment activities in the form of complex exercises, peer tutoring, and multiple-source research, among others, can be assigned.

The possibility of using different types of didactic materials (videos, slides, and animations) and tests during a course makes virtual learning environments exemplary tools in terms of integrating Mastery Learning with ICT. In this regard, the use of virtual worlds become feasible in what concerns the use of multimedia resources and distance learning activities according to the preference and availability of the student. Therefore, the interconnection of these two areas emerges as a possibility of developing a method based on the best principles and resources both can offer.

5.   Research Method

The present article devises a one-off study on new pedagogical practices, covering different teaching domains such as Physics, Science, and Computing. In essence, this study is centered on two interdisciplinary strands: virtual worlds and Mastery Learning. Based on these two approaches, this article aims to discuss and propose a teaching method that seeks to improve the learning process of students at different school levels.

5.1.   Research Design

This study is a(n) explanatory (or causal) research, and it intends to identify the extent and nature of the cause-and-effect relationship. The procedure consists of a quasi-experimental intervention in traditional teaching methods, aiming at investigating the effects that different approaches may have on student learning, and what particularities can be observed during this process, based on the results obtained.

5.1.1.   The proposed method

In the original process of the Mastery Learning theory, students follow a sequential path, with periodical tests, and if they do not obtain the required level, they need to undergo remedial activities and retake the test. This way, they cannot go on to the next topic until they have reached the minimum performance level, which demands an extra load of time each new cycle.

In the adaptation proposed, the students must also follow, sequentially, a previously established path. However, if they do not obtain a satisfactory level, their learning difficulties will be solved by remedial activities throughout the course, in parallel with the other regular activities. Having the opportunity to catch up with the lessons in real-time and keep attending the mainstream course, the student's progress will not be 'blocked'. This procedure is considered one of the main distinguishing features of the proposed method, combined with the use of virtual worlds.

Figure 1 displays an overview of how the proposed method works, in an attempt to explain its operation to the reader. The scheme was designed to demonstrate that the process occurs sequentially.
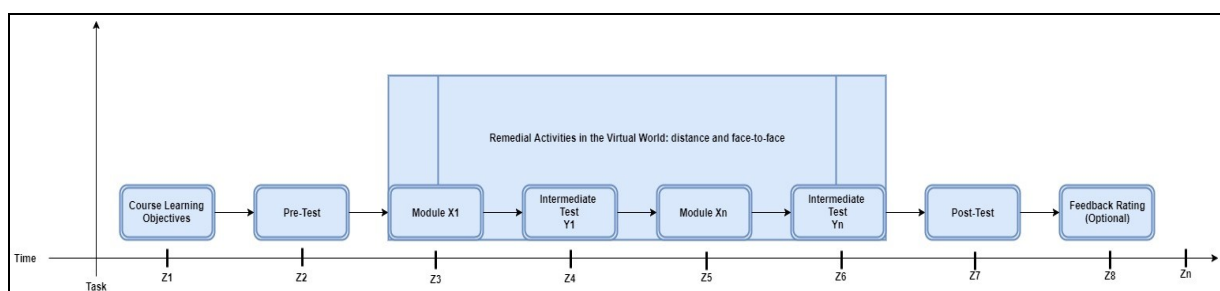

Figure 1: Process flow diagram of the proposed method
Source: created by the authors of this study.

As shown in Figure 1, the process begins with the students' first class, in which the teacher explains the course learning objectives in order to make students aware of the topics that will be taught and the way activities will be conducted (time $Z1$). After this, a first test (here called Pre-test) is applied, covering all the topics that are planned to be addressed throughout the course, in an attempt to measure the students' initial knowledge (time $Z2$). If preferred, the teacher can apply questions sorted by topic (open-ended or multiple-choice questions), making it possible to analyze topics separately and hence the student's level of knowledge in each one.

Subsequently, the teacher begins the activities planned for the first module (X1), according to his/her preference and based on the syllabus (time Z3). It is important to emphasize that the teacher can choose the best way to deliver the topics' content, either by lecturing with the help of a blackboard and oral explanations, slideshows, multimedia resources as videos or by using other technological resources.

At the end of the first module, an intermediate test (Y1) is applied, covering only the topics taught in that period (time Z4). The teacher should assess the performance of each student to identify those with the most significant learning difficulties. This process is an integral part of the ongoing monitoring of the students' performance along the course to obtain a real-time overview of the learning achievement of each student and the class as a whole, so that corrective measures and improvements can be implemented.

Students who scored below the satisfactory performance established by the teacher are asked to take remedial activities parallel to the course. This prevents changes in the normal flow of the class, thus complying with the workload defined in the syllabus. It is common to observe that in the traditional methods adopted in several formal educational institutions this moment takes place only at the end of the course after all the grades are filed, in the form of a "catch-up period" with supplementary exams.

In the proposed method, remedial activities are offered through a virtual world, being up to the teacher to decide the best way to deliver it, either by face-to-face activities with the students in the computer lab, during class time or in an alternative schedule. Additionally, the teacher can opt to use the distance-learning format, assigning tasks to be done in the virtual world. Also, the teacher can decide if the remedial activities must be done for all students regardless of their performance on the tests, if considered appropriate.

Therefore, a small cycle ends – the first module is completed, a test was applied, and remedial activities about that topic were offered. From that moment on, the same procedure is adopted for the second module (X2), with the possibility to address it differently (time Z5). An intermediate test (Y2) is then applied at the end of this module, covering only the topics studied thereof (time Z6). Subsequently, the teacher will assign new remedial activities to be done in the virtual world.

The same procedures can be followed in the eventual next modules (XN) according to the teacher's plan, with intermediate tests (YN) at the end of each one, until all topics in the syllabus are covered. At the end of this process, the teacher will apply a final test (here called Post-test), which will include all topics taught in the course. This test must be different from the Pre-test applied at the beginning of the course (time Z7).

As an optional procedure, at the end of the process, the teacher can interview students or ask them to complete a questionnaire assessing the method, the way the activities were carried out, and their impressions about the virtual world (time Z8). This enables the teacher to collect important information on students' opinions and analyze constructive criticisms and suggestions that may lead to improvements.

Finally, the cycle of the proposed method is then completed, following the topics according to the syllabus and without the use of additional time for the remedial activities, that is, without blocking the student to keep progressing. Another aspect that stands out in this method is the constant monitoring, giving the teacher an updated record of the students' performance, thus enabling him/her to proactively take the necessary measures to improve the learning process, also preventing the student from reaching the end of the course with a cumulative lack of knowledge.

5.1.2.   Procedure

To analyze the impact of this method in a real class context, an experiment was carried out in the school year of 2017, which lasted approximately four months (from March to July). The course considered in the study was a Science class, and the topics addressed in the period were divided into the following three modules, whose learning objectives were explained at the beginning of the course:

1.   Constitution of Matter – atoms and molecules;

2.   Physical and Chemical phenomena and Sources of Energy;

3.   Soil and Health – pollution and diseases.

At the beginning of the semester, it was explained that all students would have free access to supplementary materials and activities throughout the course, which were delivered through two different platforms: the virtual world and the Moodle learning environment. Students were free to choose one of the platforms, so two groups were randomly formed: one using the virtual world and the other using Moodle.

The course consisted of a weekly class of 45 minutes, with weekly supplementary activities to do at the distance modality using the virtual world or the Moodle learning platform. Students of the two groups took five tests along the process, elaborated and applied by the teacher in printed format in the classroom.

For the virtual world group, two initial face-to-face classes were held with the students in the school's computer lab, with the presence of the researchers for observation. The aim was to facilitate the process of familiarizing students with the use of the virtual world, in which they received instructions on how to set up the viewer and navigate the environment. Singularity viewer was selected for this purpose, by being robust and having Portuguese language support.

5.1.3.   The virtual world for Science learning

A virtual lab was created in the virtual world, with a structure divided into five different types of rooms according to the didactic material available: videos, texts, slides, quizzes, and simulations. At the entrance of the virtual lab, a space was built with different types of clothing options for users to customize their own characters (avatars).

In the video room, there were six large panels for better video viewing. Its mode of operation consisted of media textures and access to YouTube (through the Internet), with each panel containing a different module. A chair was placed in front of the panel, so that the avatar could sit at an angle that favored the viewing of the contents.

With regard to the text and the slides room, the panels displayed image textures for the content presentation, with control buttons. In the quiz room, each panel contained a quiz displaying questions in image format, with answer buttons at the bottom and a board indicating the module to which the quiz corresponded. By clicking on the chosen alternative, the respective option turned blue, and feedback was provided on the student's chat channel, informing whether his or her answer was correct or wrong. It was possible to repeat the quiz as many times the user found necessary.

In the simulation room, several 3D animated representations and experiments related to the topics covered in the three modules were available. In total, 15 simulations were built in the virtual world. Each one had a totem with a red button to indicate its beginning, and the simulation status step by step was provided on the user's chat channel.

Figure 2 illustrates the module about the Constitution of Matter, showing 3D representations and the structuring of elements. Figure 3 displays some of the experiments related to Physical and Chemical phenomena, all of them were animated and demonstrated how each process occurs. At the bottom, it can be seen a capsule with four atoms to represent the movements in the three physical states of matter: gas, liquid and solid.
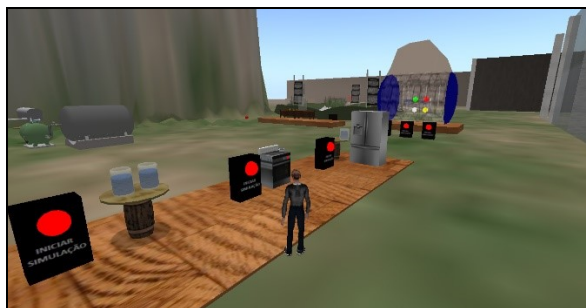

Figure 2: Constitution of Matter

Figure 3: Physical and chemical states of matter
Source: created by the authors of this study.

Moreover, a space was created especially for the simulations about the topic Sources of Energy, with experiments predominantly static and visual, with no animations added. Because this topic is just introductory, the processes involving each type of energy source did not need to be explained in detail. Therefore, the choice of using predominantly images and texts was made by the teacher. The Soil and Health module was contemplated with the creation of simulations involving aspects of ecological maintenance, good practices with the environment, and various sources of pollution.

5.2. Participants

The experiment included three classes of sixth graders, in a Science class at a Brazilian public school. However, 12 students who did not take one or more of the tests during the period investigated were excluded from the sample, as their participation would not be valid according to the process of analysis planned for the results. In this way, the resulting sample comprised 74 students, who were then divided into 2 different groups, merging the three initial classes, as follows:

Group 1: 46 students who chose to do supplementary activities in the distance modality using the Moodle learning platform;

Group 2: 28 students who chose to do supplementary activities in the distance modality using the virtual world;

As previously mentioned, the 28 students using the virtual world had two introductory classes to become acquainted with the mode of interaction of the platform and to learn about the necessary

procedures for distance access. It is important to mention that the participants used the environments freely and by their own will and motivation.

5.2.1. Instruments

The method proposed in this study was rigorously and consistently followed during the experimental period, in which the students of the two groups took five tests along the process.

The first test was a Pre-test applied on the first day of class covering all the topics planned for the three modules, containing eight multiple-choice questions. None of the students had taken any classes about the topics covered in the experiment before. At the end of each module, an intermediate test was applied. Finally, at the end of the process, a Post-test covering all the topics of the course was applied, containing 17 questions, some of them multiple-choice and some open-ended questions, but different from those in the pre-test.

At the end of the experiment, students who used the virtual world (Group 2) also answered a printed questionnaire with eight multiple-choice questions and two open-ended questions. The multiple-choice questions had five alternatives ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), as established on the Likert scale. Cronbach's Alpha was applied in order to ascertain the reliability of the participants' answers by finding a correlation between the answers, with a result of 0,724425, representing data with high reliability. This questionnaire aimed to gather pertinent information about the resources explored in the environment, the virtual world itself, and the students' perception of the approach.

Finally, interviews were conducted with several students randomly chosen from both groups, to raise more detailed information about the use of the virtual world and Moodle platforms, and about their experience with the proposed method.

5.3. Data Analysis

For the analysis of the five knowledge tests applied in both groups, statistical tests were applied aiming at comparing groups and verifying the existence of significant differences. Thus, the non-parametric hypothesis tests selected for this purpose were the Kruskal-Wallis for three groups and the Wilcoxon-Mann-Whitney for two groups. The analyses were performed using the statistical software IBM SPSS version 18, at a 0.05 significance level. Two hypotheses were formulated for the study:

Null Hypothesis (H0): there is no difference between the median performances of the groups;

Alternative hypothesis (HA): there is a difference between the median performances of the groups.

For the analysis of the virtual world perceptions, the K-Means clustering technique was used with the support of Statistica software. In order to define the number of clusters to be formed using the K-Means algorithm, a tree diagram analysis was performed, through the use of Ward's clustering method and Euclidean distance.

6. Results

The results obtained in the present study can be analyzed from two different perspectives. The first one is centralized in the statistical analysis of the groups' performances on the knowledge tests (n=74), and the second in the questionnaire answered by the virtual world group (n=28), as follows.

6.1. Knowledge tests performances

First, it was examined if the three classes had homogeneous performances in the tests, to determine if analyses sorted by class were required, in addition to the analysis by groups. Table 1 presents the results obtained, considering the median value for each class. The p-value is above the established significance level of 0.05 in all cases. This way, it is possible to assume that the three classes were homogeneous and that a joint analysis can be carried out.

Table 1: Analysis of results by classes

Class	Pre-test	Test 1	Test 2	Test 3	Post-test
Class 1	60.00	84.00	90.00	100.00	83.00
Class 2	50.00	88.00	87.50	87.50	83.00
Class 3	60.00	92.00	90.00	85.00	83.00
p-value	0.085	0.658	0.55	0.108	0.745

Source: output from the analysis performed on SPSS v. 18.

Based on this finding, a comparison by groups was performed. Table 2 displays the results of this analysis, where Group 1 represents the students who used Moodle and Group 2 the students who used the virtual world.

Table 2: Analysis of results by groups

Group	Pre-test	Test 1	Test 2	Test 3	Post-test
1	50	84	85	90	83.0
2	60	94	90	90	84.5
p-value	0.265	0.044	0.297	0.347	0.309

Source: output from the analysis performed on SPSS v. 18.

As shown in Table 2, in the **Pre-test** the median of Group 2 (60.00) had a higher value in relation to Group 1 (50.00), but the null hypothesis of equality for this case was maintained, as there were no significant differences (p=0.265).

In **Test 1** (Figure 4), significant differences were observed in the medians, so the null hypothesis was rejected in this case (p=0.044). The median of Group 2 (94.00) was higher than that of Group 1 (84.00). Moreover, the score concentration in Group 2 is better distributed and has a smaller amplitude, confirming less variability of the data to the point of becoming significantly different when compared to the results of Group 1.

Regarding **Test 2**, the median of Group 2 was 90.00, which was higher than that of Group 1 (85.00), but no significant difference was found (p=0.297). The score concentration is similarly distributed in both groups, as well as their amplitudes, which indicates that both groups had similar variability. Therefore, the slightly higher median value of Group 2 is not significant, as it just represents a slightly better performance of the participants.

The box plot diagram of **Test 3** shows equal medians in the two groups (90.00), with no significant difference (p=0.347). However, the data in Group 2 have a more concentrated distribution, lower amplitude, and hence lower variability, showing that the scores were more constant in comparison to Group 1.

Finally, the **Post-test** presented a slightly higher median for Group 2 (84.50) compared to Group 1 (83.00), as shown in Figure 5. The distribution of data is also better concentrated in Group 2, presenting smaller amplitude and consequently a smaller variability of scores. This points to a slight improvement in the performance of Group 2 in relation to Group 1, however without significant differences (p=0.309).
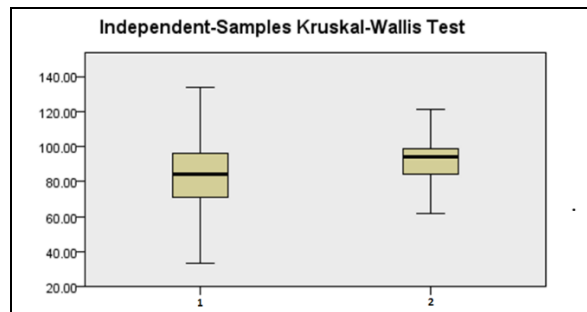

Figure 4: Box Plot diagram of Test 1
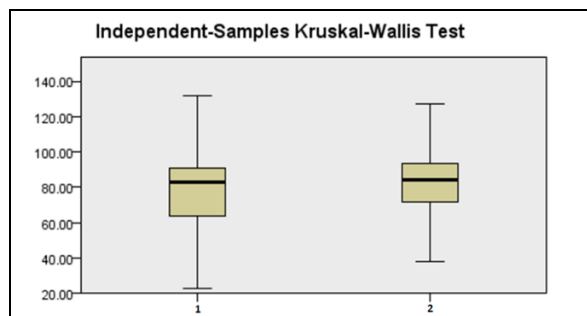**Source: output from the analysis performed on SPSS v. 18.**

Figure 5: Box Plot diagram of the Post-test
Source: output from the analysis performed on SPSS v. 18.

In this manner, the analysis of the results presented a scenario in which it is possible to infer a better performance of the virtual world group in relation to the Moodle group, even though it was small and not significant. The performances in the intermediate tests (Test 1 and Test 2) were better for Group 2, although they had higher scores in the Pre-test. What reinforces this result is that the score distributions appeared to be better concentrated in the virtual world group, with smaller amplitudes and less variability in the intermediate and Post-test.

6.2. The Virtual World Perceptions

The K-Means clustering algorithm was applied to the answers given to the questionnaire, creating clusters to facilitate the analysis. The number of two clusters was defined using the tree diagram analysis by using Ward's method combined with Euclidean distance.

Figure 6 shows the two clusters automatically formed in the classification of the answers, called "Cluster 1", containing 9 users, and "Cluster 2", containing 19 users.
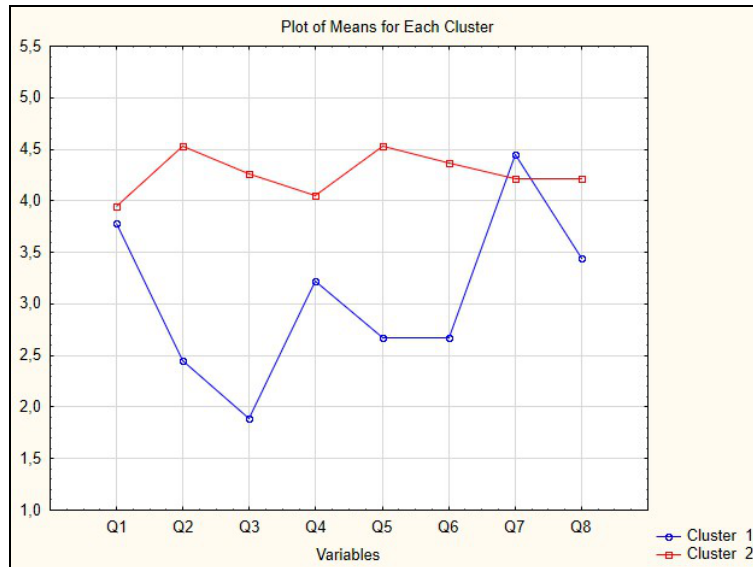
Figure 6: Cluster analysis of the questionnaire
Source: output from the analysis performed on Statistica.

Question 1 referred to the consistency of visualization and correctness of the 3D objects rendering in the virtual world, in which the answers of both clusters were close to four, thus evidencing consent. The virtual world was entirely inspected to reduce the size of the objects and make the environment faster and easier for user interaction, so this score can be considered satisfactory, as no bigger problem was reported in this regard.

Question 2 referred to the interaction with slides, videos, and texts, in which a clear division in the users' opinions was observed. Cluster 2 users were satisfied with this aspect, but Cluster 1 users demonstrated a certain level of dissatisfaction. The same opinion was observed for **Question 3**, which referred to the interaction with the quizzes available in the environment. According to comments of students from Cluster 1, the main problem was that the videos took too long to load, probably due to limited internet connection speed, thus leading to some frustration. The same dissatisfaction was reported about the slides and texts, which took longer than the expected to load.

Questions 4 and **5** referred to the correct functioning of the simulations, also inquiring students if the phenomena studied in class were correctly represented and helped them to retain more of the theoretical topics in a practical way. The answers of Cluster 2 were more positive, agreeing with the assertions, while those of Cluster 1 were in the halfway zone, appearing to be more neutral.

Question 6 inquired if the students considered that the use of the virtual world, both in the computer lab and at their homes, aided in their learning process. The answers were predominantly positive in Cluster 2, while Cluster 1 again remained neutral about the question. This result can be considered positive, as the majority of them pointed out that this type of environment did foster learning.

Question 7 was the only one higher for Cluster 1. It referred to whether the students approved the method proposed in this study. The feedback was predominantly positive, therefore confirming that they did approve it, which is in line with the results obtained by the statistical analyses.

In **Question 8** again Cluster 1 rated it lower than Cluster 2 students. In the comments, most students stated that more classes in the computer lab would have facilitated their interaction with the virtual world. Two face-to-face classes were held at the school's computer lab, and it would have been difficult to have additional lab classes, as it would interfere in the teacher's plan.

Cluster 1 students seem to have been more prejudiced with technical problems, as the limited Internet connection speed. However, as they are composed of less than half of the sample (n=9/19), this shows that overall the students were satisfied with the experience, and, by consequence, that the dissatisfaction can be related with technical difficulties in navigating the environment, not with the virtual world itself.

Regarding the two final open-ended questions, the first one referred to problems and difficulties identified by the users during the testing period. Most of the students reported that in their homes the virtual environment (the viewer) froze at times, which probably occurred due to hardware limitations of their computers. Other difficulties were mentioned, as the visualization of the slides, the loading of the quizzes and the avatar customization.

The second open-ended question asked the students to express their opinions about the virtual world and tell what they liked about it. The sense of approval was predominant, as they reported enjoyment in using the environment, despite the few problems faced. They also positively highlighted the possibility of simulating the phenomena studied only theoretically in the classroom, classifying the experience as a new way of learning.

In the interviews, participants positively highlighted the visual and interactive aspects of the environment, considered as a distinguishing feature in comparison to Moodle. The virtual world was also considered by students as fun and cooperative, because of the possibility of talking with classmates to clear up doubts in real time through chat in the environment. They also positively highlighted the resources of slides, quizzes, and simulations, especially the latter, as major strengths of the virtual world, reinforcing the characteristics of immersion, by saying that it "holds the user's attention."

7.   Conclusions

The form of interaction provided by a virtual world alludes to a more active learning, in which users become precursors of their own learning process, as they are free to navigate and access different types of didactic materials in 3D personification.

Along with this type of experience is the adoption of consolidated educational approaches and theories that help to guide the way didactic activities are conducted. Among the different proposals disseminated in the academic milieu, the Mastery Learning theory stands out for being widely recognized, based on remedial activities and constant assessment of the students' learning achievements. However, its discussion in the academia is divided between proponents of its use and opponents, who highpoint its weaknesses.

In this context, this study sought to explore the Mastery Learning potential in the educational field, structuring didactic activities to be performed in a virtual world. The search for related work in the literature revealed a scarcity of research involving both areas (Mastery Learning and virtual worlds) in an integrated way, a fact that motivated the development of this research.

In order to explore the integration of these areas and to overcome their limitations, this study aimed at developing a method that could contribute to the teaching and learning process. Although drawn from the Mastery Learning principles, the proposed method was adapted to provide greater flexibility (less instructional), take less time for implementation and not interfere in the teacher's workload. The method was carried out in a consistent manner, tested with different classes, elucidating its feasibility, educational benefits and positive impacts on students.

In this method, the use of virtual worlds was proven to be effective as a support tool for supplementary/remedial activities. It is worth noting that it does not disregard the use of the Moodle

platform, as the two environments in question have different positive characteristics. As pointed out by Kostarikas, Varlamis, and Giannakoulopoulos (2016), virtual worlds are not designed to manage content; although they allow you to include media, store and manage documents, this is still a costly process with rudimentary import and export capabilities. In addition, the authors clarify that a two-dimensional platform such as Moodle strengthens students' sense of security by facilitating access to the subject, news, announcements, and grades. This way, we conclude that it is quite possible to use Moodle (if necessary) in harmony with virtual worlds.

The experiment application yielded results that can be considered very positive and satisfactory, with emphasis to the great potential of the virtual worlds to be explored as an additional resource in the teaching and learning process. Student acceptance is an essential factor that upholds the instigating results obtained. Problems and difficulties were clearly identified, focusing mainly on the use of the virtual environment, however not incisively affecting the method.

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