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The influence of a learning object with virtual simulation for dentistry: A randomized controlled trial

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ABSTRACT

Objective: The study aimed to evaluate the influence of virtual learning object (VLO) in the theoretical knowledge and skill practice of undergraduate dentistry students as it relates to zinc phosphate cement (ZPC).
Methods: Only students enrolled in the dentistry course the course were included in the trial. Forty-six students received a live class regarding ZPC and were randomized by electronic sorting into the following 4 groups: VLO Immediate (G_{IVLO} $n=9$), VLO longitudinal (G_{LVLO} $n=15$) and two control groups without VLO (G_{IC} $n=9$ and G_{LC} $n=13$). The immediate groups had access to VLO or a book for 20 min before the ability assessment, whereas the longitudinal groups had access to VLO or a book for 15 days.
Results: A pre- and posttest on theoretical knowledge and two laboratory skill tests, evaluated by blinded examiners, were performed regarding zinc phosphate cement manipulation in all groups. The students who used the VLO obtained better results in all the tests performed than the control students. The theoretical posttest showed a significant difference between the longitudinal groups, G_{LC} (6.0 ± 1.15) and G_{LVLO} (7.33 ± 1.43). The lower film thickness presented with a significant difference in the VLO groups: (G_{IC} 25 ± 9.3) and G_{IVLO} (16.24 ± 5.17); G_{LC} (50 ± 27.08) and G_{LVLO} (22.5 ± 9.65). The higher setting time occurred in the VLO groups, and the immediate group showed a significant difference (G_{IC} 896 ± 218.90) and G_{IVLO} (1138.5 ± 177.95).
Conclusions: The ZPC manipulated by the students who used the VLO had better mechanical properties in the laboratory tests. Therefore, the groups that used the VLO had clinical handling skills superior to its controls and greater retention of knowledge after 15 days.

1. Introduction

Distance learning has existed for over a century, and its media diversity has evolved during this time, from mailing to web-based technologies that enable the use of more sophisticated teaching tools [1]. Distance learning using the web has broken the paradigm of learning in place and reinforced the idea of student-centered learning without the presence of a teacher [1]. Regarding health education, distance learning has been an effective way to enhance the knowledge of professionals in continuing education [2]. Compared to traditional education methods, distance learning shows inconsistency and heterogeneous results because of the various interventions applied; however, Internet-Based Learning is associated with positive outcomes [3], principally when use VLO as a resource learning.

Learning objects are reusable digital resources attainable for distribution throughout the network to achieve various population sizes [4]. These objects, comprising texts, graphics and animations, should facilitate the learning process by creating an attractive, interactive environment of easy navigation in electronic media [5]. In this context, virtual reality has been shown to be a potential tool in the teaching-learning process [6], being able to overcome traditional teaching methods [7]. To assist the educational process, gamification techniques have been used as elements with design

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techniques and game mechanics in different contexts. E-learning platforms have the potential to increase students' motivation with aspects of gaming [8,9]. These digital games have a positive effect on education, although more randomized clinical trials are needed to provide more rigorous evidence of their effectiveness [8,10]. In the health area, research should be conducted to evaluate a static methodology with an active learning approach such as games and virtual simulations [11,12]. In dentistry, there is research positively associating the interactivity of learning objects to undergraduate teaching [13]. However, there are no studies evaluating the relationship between virtual simulation and gamification in the learning process for dentistry students.

In dentistry, there are a variety of dental materials that could be used in patients, and these materials include zinc phosphate cement. Zinc Phosphate Cement (ZPC) is a water-based cement, in use for over one-hundred years in dentistry; it provides retainment of prosthetic devices on the remaining tooth structure [14]. Proper adaptation between a prosthesis and tooth interface requires cement with ideal properties. An appropriate amount of powder and liquid, associated with correct handling of the mixture of these components, is essential. These properties are the film thickness and setting time. Proper handling includes the disposal and cement adaptation at the interface, and the latter is the time in which a dentist will have from the beginning of handling to the moment of the hardening of the cement. A low film thickness leads to a lower interface between the prosthesis and tooth, preventing recurrent caries. In the setting time, a longer time yields a better result because of the extra working time the professional have to place the material in the prosthesis device and cement it to the patients' tooth. Both properties are directly linked to the correct manipulation of ZPC, and there is no studies evaluating the influence of different teaching methodologies at handling skills and cement properties.

In the literature, several studies have compared the outcomes of different teaching methodologies, as "e-learning" and instruction in the classroom [15–18]; virtual simulations have been used for teaching in medicine [9], highlighted by anatomy and surgery disciplines [19,20]. However, those studies failed to appraise the clinical performance of these students [21]. Other studies showed the effectiveness of VLO in health care for medical students as instruction tool in the analysis exams [22]. Many studies using Information Technology have been developed for health education as virtual simulation with serious game [23,24] intending to qualify the training of these professional [6,9]. In addition, assistance tools have been created to qualify clinical practice not only for training but also as a quick reference guide to support clinical decision [25]. However, these studies are predominantly related to users and not applied to dentistry undergraduates [24]. The use of e-learning tools in dental materials has shown popularity and approval among students [26]. The influence of VLO in association with the theoretical and clinical performance of undergraduate students it is not properly known. As the outcome, we evaluated the influence of a VLO in theoretical knowledge and skill practice in undergraduate dentistry students, relative to zinc phosphate cement.

2. Methodology

2.1. Design

This study used the CONSORT Statement to develop the randomized controlled trial (RCT) [27] performed with undergraduate students of dental materials at the Dental Materials Laboratory of Federal University of Rio Grande do Sul. The exclusion criteria were participation in all stages of the study and not having had previous access to the content. The local Ethics in Research Committee approved the study, and all students signed a consent form (CAAE: 37347214.6.0000.5347).

All current students enrolled in a dental materials class were eligible for this study; the forty-six undergraduates were allocated by coin flip to the following two blocks: the immediate and longitudinal groups, after they were divided by electronic random allocation into four groups. The group distributions are shown in Fig. 1. The four groups are as follows: G_{IC} (use of a traditional teaching method and tested immediately, $n = 9$), G_{IVLO} (use of VLO and tested immediately, $n = 9$), G_{LC} (use of a traditional teaching method for 15 days, $n = 13$), G_{LVLO} (use of VLO for 15 days, $n = 15$). A 50-min live class showed the basic fundamentals regarding the agents in dental cementation, with an emphasis on zinc phosphate cement, for all groups. After the class, a theoretical knowledge pretest was given, which consisted of 10 true or false questions about the properties and characteristics of zinc phosphate cement. Four students did not attend the class and were excluded from the research.

Next, a practical lesson was presented, in which the students manipulated zinc phosphate cement for the first time. Two groups received intervention, as follows: the G_{IC} group was given a chapter of a standard reference book [28], and the G_{IVLO} received a VLO available for laptop computers. Both groups had 20 min with their study materials. Then, they manipulated the zinc phosphate cement.

For the G_{LC} and $G_{LVLO,}$ the practice lesson took place after 15 days, so it relinquished the book and the VLO, respectively, for that period. The G_{LVLO} had access to the VLO via the virtual learning environment Moodle 2.5 and made use of the discussion forum, which had been taught by the teacher who had taught the live class. After the 15-day period, the practice class occurred, and G_{IC} and G_{LVLO} manipulated zinc phosphate cement for the first time. Four students did not attend the practical class and were excluded from the research. The study design is shown in Fig. 2.

2.2. Development of the virtual learning object

The VLO was developed in partnership with the Open University of the Brazilian Public Health System of Federal University of Health Science of Porto Alegre. The VLO content was exactly the same as that of the live class and was developed by the same teacher in Articulate Storyline 2 (Articulate Global, Inc., New York, NY—USA) software. The object was composed of narrated illustrations, a video demonstration and virtual simulation of cement handling (http://www.ufrgs.br/lamad/fosfato-de-zinco/fosfato-de-zinco/view).

2.2.1. Virtual simulation

Virtual simulation was the last stage of the VLO. After attending to all classroom content and seeing the manipulation video, each student was expected to perform the simulation. A video tutorial explained the simulation, which was the use of a spatula held with a click and dragged over a glass plate. The following two variables were considered: the handling frequency and the used area of the plate. The student should receive maximum points for these two variables in the established pre-manipulating time for each cement powder increment. At the end of each incremental time, the student received positive or negative feedback, depending on the performance. At the end of the handling of all powder increments, the student received a final grade, which was stored by Moodle. Fig. 3 shows the process.

2.3. Creation of the pre/posttest

To evaluate the theoretical knowledge of students, a pre and posttest was developed. Ten questions regarding the cementing agents and zinc phosphate cement were prepared in a true or false