

# Radiographic interpretation of changes in the tooth and adjacent bone tissue using the tools of the Moodle virtual environment

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## ABSTRACT

Virtual learning environments (VLEs) have numerous possibilities for the use of their tools and can assist in the processes of teaching and learning about the radiographic image interpretation. This study aimed to evaluate the use of a virtual learning environment as a support material for students in the discipline of Dental Radiology. This radiographic interpretation was conducted to contribute to the knowledge and training of the changes in the tooth and adjacent bone tissue, visualized in periapical and interproximal radiographs. The scores of the virtual test (via the Moodle platform) and the interpretation test (in the classroom) were used to compare Group Number 1 (students that performed the virtual test before the classroom test) and Group Number 2 (students that performed the virtual test after the classroom test). It was observed that, in general, the mean score of the interpretation test was higher than the virtual. Also, 66% of the students used the platform as the main resource to follow the discipline, due to the possibility of reviewing the contents and activities. The virtual learning environment can be considered an important complementary source for teaching radiographic interpretation. The Moodle platform acts as a remarkable tool, with the potential capacity to support the teaching and learning process. For this, mutual collaboration among students, University, and educational institution is necessarily required for the constant use, maintenance, and updating of the virtual environment.

**Descriptors:** Learning. Moodle. Education in Dentistry. Radiology.

## 1 INTRODUCTION

One of the great challenges for teachers is to keep up with the changes in the perception of learning, as well as improving the ways of evaluating the students. The choice of materials and technological tools is an alternative for the improvement of methodologies that can be used through various platforms and Virtual Learning Environments (VLEs). Among these is Moodle

(Modular Object-Oriented Dynamic Learning Environment), which allows for the use of different forms of communication and interaction, which like other situations, are dilemmas faced by teachers in their teaching practice<sup>1</sup>.

The didactic activity that is built into a virtual environment offers the student the opportunity for an autonomous initiative in academic life. VLEs have several possibilities through useful tools, to

improve the opportunities for the creation and development of students. Importantly, the teachers and the educational institutions must have the knowledge and mastery of the potential of these tools, so they can make appropriate use of these resources while providing meaningful learning. VLEs are progressively being used as tools for these different phases of the teaching and learning processes<sup>2,3</sup>. Moodle is an environment of diversified pedagogical skills, by which teachers can develop a new way of connecting with the students, promoting an improvement in the transmission of knowledge through a virtual format<sup>4</sup>.

Periapical and interproximal radiographs are widely used by dentists. They are of fundamental importance in clinical dentistry, as they are essential for obtaining complementary information for diagnosis and treatment planning. The periapical radiograph allows for a detailed evaluation of the teeth and the surrounding tissues. This type of radiograph is used mainly to evaluate the morphology of the pulp chamber and the root canals, as well as to analyze the bone and alveolar support structures in the interdental region while detecting periapical pathologies and fractures in the crown/root region. It is especially useful as an endodontic appraisal for a pre-treatment evaluation of the roots, calcifications, and curvatures, as well as for the determination of the working length, quality, and the extent of root canal filling, together with post-treatment monitoring<sup>5</sup>. Interproximal radiography presents high accuracy in evaluating the proximal surface, and this analysis is superior to any other tooth surface method<sup>6,7</sup>.

At this complex time, the world has been forced to adapt and live with the risks of the COVID-19 pandemic, which has brought many challenges to education. Universities, in particular those with degrees in health care, have needed to create safety strategies for their teachers, students, staff, and patients. Innovative teaching tools have

had to be implemented immediately with care<sup>3</sup>.

The Moodle platform is an ongoing development project that is being used to support social constructivist education. This virtual environment consists of a didactic and pedagogical activity management system, with a package of programs that are designed to help educators achieve high-quality standards in online directed learning tasks. This system generates educational learning environments, which are known as e-learning, learning management systems (LMS), or VLEs. The incorporation of Information and Communication Technologies (ICTs) for the educational scenario has enabled the reevaluation of the way education is practiced, establishing a new paradigm for teaching and learning<sup>4,8</sup>.

VLEs are didactic alternatives that are used collaboratively along with classroom teaching, to contribute to and test the knowledge of the students. Thus, this study aimed to evaluate the use of the Moodle platform, as a support material for students that realized the virtual activities in distinct moments (before and after classroom), in the teaching and learning process of the Dental Radiology discipline. This Moodle platform would be applied for the radiographic interpretation of changes in the teeth and the adjacent bone tissue, as visualized in the periapical and interproximal radiographs.

## 2 METHODS

This research was characterized as a descriptive study, with a quantitative and qualitative character. It was approved by the Research Ethics Committee (REC) of the Pontifical Catholic University of Rio Grande do Sul (PUCRS) (Protocol CAAE 02958918.9.0000.5336).

The sample consisted of dental students from the School of Health and Life Sciences (SHLS) of the PUCRS, who were enrolled in the Dental Radiology discipline. This discipline

includes didactic-pedagogical content that is related to the radiographic interpretation of changes in the normal aspect of the tooth and adjacent bone tissue, visualized in periapical and interproximal radiographs. The 66 students were divided into six groups (A1, A2, B1, B2, C1, and C2). Groups Number 1 performed the virtual activities (via the Moodle platform) before the face-to-face test, while Groups Number 2 conducted the virtual activity, after the face-to-face test. The null hypothesis of this study was that there is no difference between the students' learning doing the virtual supplementary activity before or after the face-to-face mode.

The teaching of radiographic image interpretation was developed through theoretical and practical classes in the classroom, before assessment activities. In the Moodle virtual learning environment, the support materials relating to the content that was developed in the classroom were available on the discipline page, which could serve to support the students in the teaching process. The assessment activities that were performed on the Moodle platform consisted of radiographic images, which were associated with the exercises in the form of simple or multiple-choice questions (figure 1). These activities were entered into the Moodle platform and answered at a predetermined time, after the classroom. The questions referring to the tasks that were performed by the students, and these questions were previously designed and tested by the teachers.

First, the scores obtained from the activities performed by the students in the classroom and on the Moodle platform were analyzed. The data was compiled from the evaluative exercises that were aimed at the perceptual training, both in the traditional form and with the use of the Moodle platform. This

procedure was conducted through a practical test of the interpretation of the changes in the periapical and interproximal radiographs. These scores determined the performance of the students. These qualitative data were analysed using the open coding method. Responses from each participant were analysed in detail. Sentences, phrases, and words were studied separately in line with relation to the topic and analysed according to their relevance. Through repeated comparisons, similar ideas were integrated until major themes were established for each study question.

In a second stage, a questionnaire was applied based on the guidelines of Günther (2003)<sup>9</sup> and Gil (2008)<sup>10</sup>. The questionnaire was composed of eight objective questions, with certain questions aimed at profiling the respondents, and others to obtain information about the student's use of the Moodle platform. The students who agreed to participate in the research answered the questionnaire at the end of the academic semester. This questionnaire was used to verify and examine the students' opinions regarding the Moodle platform resources and the classroom teaching model used.

The quantitative data was organized in an Excel spreadsheet (Microsoft, Redmond, WA, USA) and analyzed to correlate the activities that were developed in the classroom teaching, with the virtual collaborative activities used. For the statistical analysis, the Student's t-test was used (for the performance analyses of the two groups: (1) the students who took the test on the virtual platform before the face-to-face test; and (2) the students who took it after the face-to-face test; this was followed by the ANOVA test (for analyses of the three classes of students separately) (figure 2). *P* values < 0.05 was considered statistically significant.

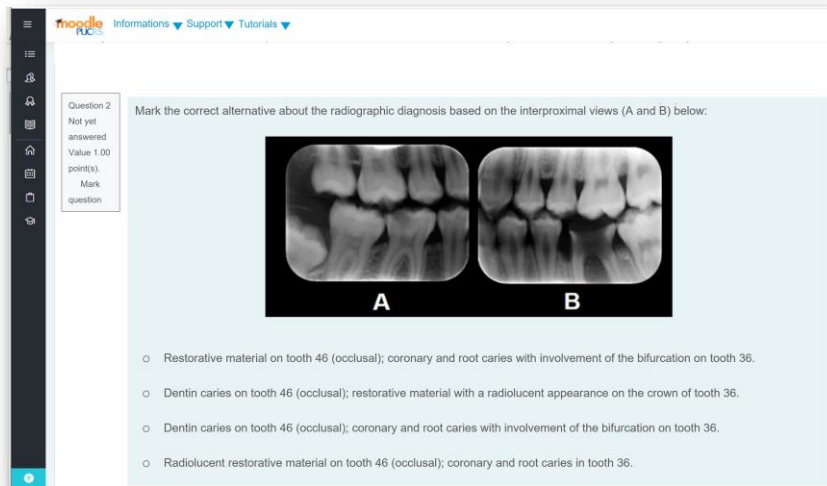
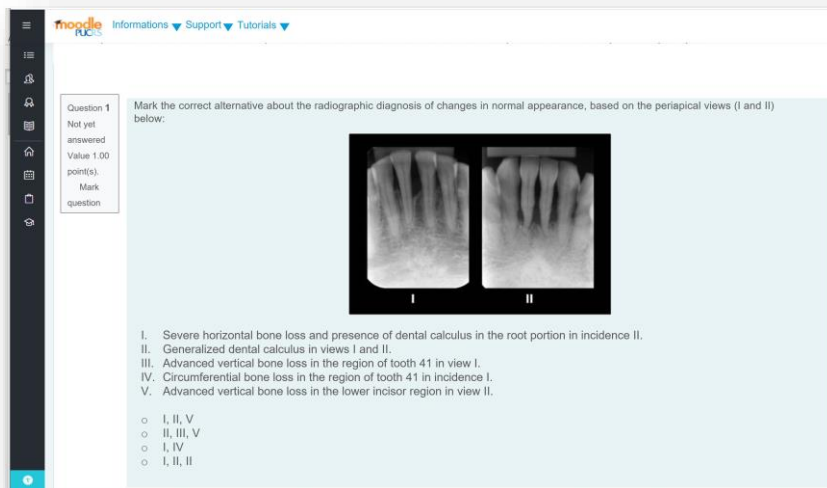


Figure 1. Examples of assessment activities that were performed on the Moodle platform

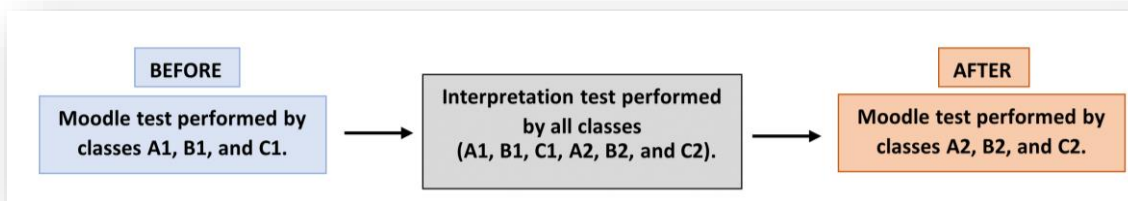


Figure 2. Flowchart showing the chronology of virtual and face-to-face activities

### 3 RESULTS

The sample included a total of 66 students, who agreed to participate in the research, and they all signed the consent

form. Through the Student's t-test, a statistically significant difference was found when comparing the face-to-face and virtual tests, obtaining *P* values of 0.001 and 0.004, respectively. In the analysis of the class in its

entirety with simple pairing, it was observed that the average grades of the interpretation test (face-to-face) were higher than the virtual evaluative activity, as performed via the Moodle platform (table 1).

Table 1. Average grades of the interpretation test comparing groups (Student's t test, by simple pairing)

		Mean	N	Standard deviation	<i>P</i> *
<b>Before</b>	Face-to-face	7.87	33	1.19	-
	Moodle	6.61	33	1.78	0.001
<b>After</b>	Face-to-face	7.69	33	1.16	-
	Moodle	6.79	33	1.41	0.004

\* values of *P* < 0.05 were considered statistically significant.

For the comparison of the three classes separately, the ANOVA test was used, which was then represented by the construction of two graphs.

In figure 3, it is possible to observe that the averages of the face-to-face interpretation activities were higher for the students in Group A1, who had previously taken the virtual test, with a value of 7.6. It is also noted that the average of the virtual activity (Moodle) of Group A1 was higher than Group A2, with a value of 7.8.

The facts that occurred in class A were repeated for class B. The students in Group B1 obtained a higher average in the face-to-face interpretation activity, with a value of 7.7. However, the average of the virtual activity (Moodle) of Group B1 that was performed previously was lower than Group B2, with a value of 5.0.

Group C2, which subsequently performed the virtual activity, obtained an average higher than Group C1 in the face-to-face activity, with a value of 8.5 (figure 4). Notwithstanding, the average for the virtual activity (Moodle) of C2 was lower than C1, with a value of 6.0; and this was contrary to what was observed in classes A

and B.

In the questionnaire (table 2), which was conducted at the end of the academic semester, the students were asked about their assessment of the virtual learning environment (question 3), with the highest average of the responses confirmed as “adequate” (72%).

In question 5, the average value of 72% for the “adequate” answer was also obtained in relation to the student's assessment of the quality of the support material, as was provided by the Moodle platform.

Concerning the didactic material, it was questioned which among the materials used was the most used for the monitoring of the content (question 6). The highest average among the responses was “Moodle virtual learning environment” (66%).

In the answers to question 8, when the students were asked about the way the Moodle platform contributed to learning the content, it was observed that the highest averages were “For the possibility of reviewing the contents and activities” (66%). Furthermore, the students mentioned the fact that the Moodle platform “allowed one to study at one's own pace” (20%).

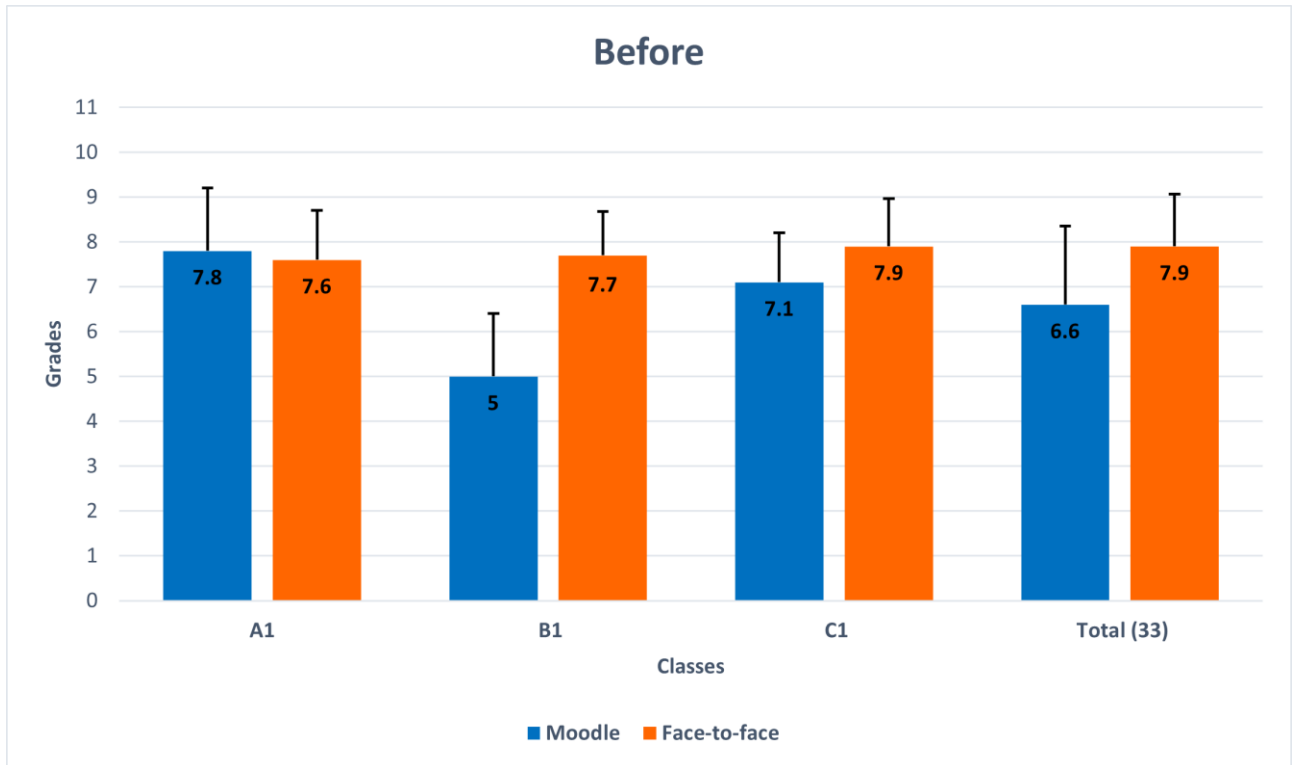


Figure 3. ANOVA test for classes A1, B1 and C1, wich performed the face-to-face activity before the virtual one (Moodle)

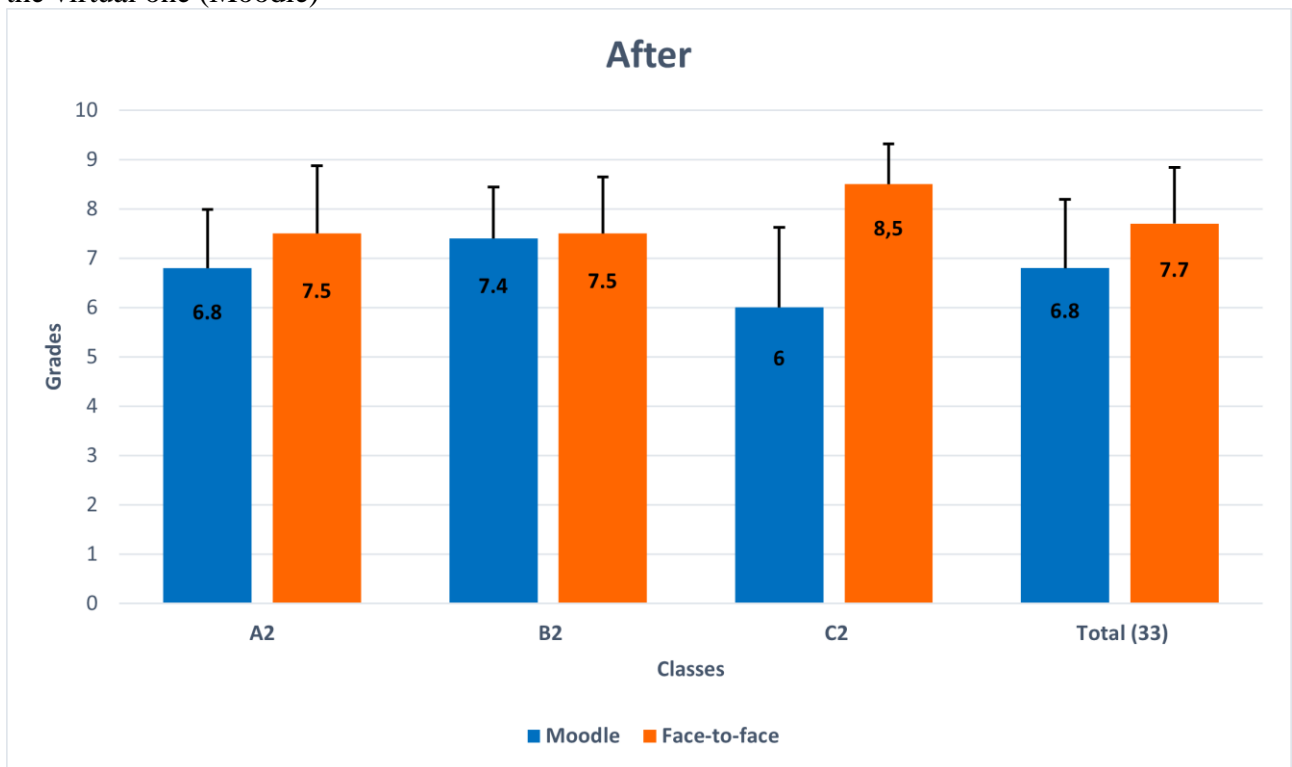


Figure 4. ANOVA test for classes A2, B2 and C2, wich performed the face-to-face activity after the virtual one (Moodle)

Table 2. Questionnaire and data collection of respondents

QUESTIONS	Classes			Total
	A	B	C	
<i>Radiographic interpretation</i>				
Very Relevant	18	15	26	59
Relevant	2	3	-	5
<i>Teaching methods</i>				
Appropriate	18	13	22	53
Partial appropriate	2	5	4	11
<i>Moodle usability</i>				
Appropriate	13	11	22	46
Partial appropriate	6	4	4	14
Little appropriate	1	3	-	4
<i>Practical activities</i>				
Appropriate	16	10	25	51
Partial appropriate	4	6	1	11
Little appropriate	-	1	-	1
Not appropriate	-	1	-	1
<i>Moodle quality</i>				
Appropriate	10	12	24	46
Partial appropriate	9	4	2	15
Little appropriate	1	2	-	3
Not appropriate	-	-	-	0
<i>Best teaching method</i>				
Book, journals, manuals	-	-	-	0
Documents and abstracts	10	5	6	21
Virtual environment	9	13	20	42
Web pages	1	-	-	1
<i>Evaluation method</i>				
Discursive test	4	3	9	16
Objective test	9	10	11	30
Group assignment	6	4	6	16
Individual assignment	-	1	-	1
Oral test	1	-	-	1
<i>Virtual environment contribution</i>				
My own pace	9	1	3	13
Convenient hours	3	2	3	8
Review the lessons	14	14	14	42
No contribution	-	1	-	1

#### 4 DISCUSSION

The use of computational environments makes it possible to present data and images systematically, promotes direct communication between the teachers and the students, as well as integrating projects to achieve the goals of the discipline<sup>11</sup>. For Lyao (1998)<sup>12</sup>, hypermedia offers important tools for the development of activities in the educational area, which can make learning more motivating and meaningful, through audiovisual resources and the ability to provide connections between concepts quickly and efficiently.

When evaluating these technologies, Kavadella et al. (2010)<sup>13</sup> observed a better result for a group of dentistry students who had face-to-face classes that were associated with online activities when compared to another group with conventional face-to-face education. The students belonging to the first modality obtained higher marks in the evaluation carried out after the research. The results showed that learning was effective and motivating, as well as the commitment and autonomy of the students to carry out their studies. A positive aspect highlighted by the students was the availability of support material for access at any time.

The application of VLEs, such as the Moodle platform, brings numerous benefits in the teaching of radiographic interpretation. This provides the teacher with the use of different resources, such as enlarging radiographic images, while inserting arrows and indicators, to facilitate the location of the changes, and to carry out the complementary support for a better understanding. While for the student, there is the possibility to review the contents according to their study routine, hence allowing for the flexibility of their learning times and places. In face-to-face activities, there are some limitations, such as the need for negatoscopes and magnifying glasses for all of the students, with simultaneous assistance for several students by the teacher, which can be quite complex.

Blumenfeld et al. (1991)<sup>14</sup> stated that the performance of university students depended on the attention that they devoted to their studies. According to these authors, this aspect can be considered as one of the main factors for success in learning. As stated by the results of the present study, the students' performance was conditioned to the grades for the end of the semester. It was observed that the students attributed a greater value to the interpretation activity, as it had a greater weight for the final grade.

Although students can easily adapt to new technologies, they still do not have the maturity to achieve the efficiency of these tools. For them, their grade remains the most attractive form of commitment and interest, and it is the teacher's responsibility to use other motivational factors<sup>15</sup>. Therefore, in this study, it was observed that the students devoted more time to study and focus on the interpretation activities, hence resulting in an average grade value higher than the activities that were performed on the Moodle platform. This fact was evident in Class C, in which Group C2, which first performed the face-to-face activity, obtained a significantly higher-grade point average in this activity when compared to Group C1.

The current generation has more access and ease to use computers and other electronic devices for communication and quick searches. Nevertheless, it is observed that they still need rewards, such as the addition of notes to use these devices, so they can employ them as tools for learning<sup>8,16</sup>. As can be seen in classes A and B, the means for the face-to-face interpretation scores of Groups A1 and B1 (who performed the virtual activity before the face-to-face) were higher than in A2 and B2, respectively. All the same, this superiority was insignificant, demonstrating that virtual learning environments need to act in a supportive way in the teaching of Dental Radiology. Face-to-face teaching has a consolidated role.



The teaching of Dental Radiology does not presuppose an approach that is performed entirely by virtual platforms<sup>16</sup>. An essential part of radiological practice comprises the improvement of manual skills to achieve the technical procedures and the interpretation of the images. These skills are difficult to develop without face-to-face physical interactions between the students, teachers, and patients. This condition is even more evident nowadays when a pandemic situation, such as that caused by the Sars-CoV-2 virus, which caused COVID-19, implied the need for social distancing, as well as the suspension of face-to-face activities<sup>3</sup>, imposing temporarily, the transmission of knowledge in a completely virtual way.

The crisis caused by the Sars-CoV-2 virus has shown that the dental academic community has underestimated the role of virtual infrastructure in the teaching of oral health, as well as in remote patient care, such as in the teledentistry service, which is still incipient<sup>16</sup>. During the distance period, there was a notable and necessary change in the way the theoretical classes were taught; it was possible to observe the constant use of platforms, such as Zoom®, Google Meet®, and the Microsoft Teams®. These systems sought to be alternatives for maintaining theoretical knowledge but for activities, such as in the pre-clinical and clinical stages, which require face-to-face teaching, the possibilities are smaller and the virtual environments are less effective<sup>18</sup>.

When considering the student's motivation, there is an obligatoriness to change the paradigms of education, to encourage autonomy on the part of the student, making learning more active. Therefore, this new scenario requires the training of teachers, necessitating from them a greater understanding of the challenges linked to the construction of knowledge that is mediated by computers. This is as well as the need to create virtual pedagogical environments, with an adequate choice of the tool for each situation,

mainly in ways to motivate the students to be active participants in the educational process<sup>19</sup>. Some ways of producing these changes would be the simplification of the navigation system in the VLE programs, the provision of self-assessment activities, and the opening of virtual forums for the students to also add suggestions for improving the development of platforms, mutually with the teachers.

In a study by Meckfessel *et al.* (2011)<sup>20</sup> four groups of students were compared. Groups 1 and 2 obtained the content of Dental Radiology through the traditional literature, while Groups 3 and 4 had access to a virtual platform (“Medical Schoolbook”), which was developed by the university itself (Hannover Medical School, Germany). At the end of the school term, the students performed a knowledge assessment. The failure rate for the first two groups (traditional education) was 40%, while for the groups with access to the virtual platform, the value was considerably lower (2%). As in the present study, in classes A and B, it was possible to show that the virtual environment has an important role in complementing the content, allowing for the students to revisit content quickly and easily, while at the same time, the information was concentrated in a single location. Even so, it is emphasized the probable interference of this facility in the formation of the student's profile. This is since the content is available in a compact and easily accessible way, as some students tend to study only on the eve of the evaluations, and they do not consult other sources of information. One way to avoid this situation is to use a schedule of support activities and evaluation exercises, helping the student to form a consistent study routine.

The same authors<sup>20</sup> also prepared a questionnaire for the students to evaluate the virtual platform. Regarding the initial opinion about e-learning, about 70% responded positively. In another question, concerning the use of the

platform for content review, there were 40% negative responses. In the current study, the result was similar for the assessment of the Moodle platform, as 72% of the students said they considered it adequate. Despite this, when the question was about the contribution of using the platform for learning the content, 66% of the answers showed the possibility of reviewing the contents and activities. These results show that although the students recognize the usability of virtual learning environments, they are still used predominantly as repositories. The functionality of providing students with a new opportunity to access content and activities, at different times and locations, is attractive to the students, who have already been born in a digitalized world (“digital natives”).

In a survey that was conducted with undergraduate dentistry students at the University of Sydney (Australia)<sup>21</sup>, 60% of the students considered the learning management system (LMS) to be satisfactory. The authors verified a high preference of students for the use of the virtual platform to replace resources and content. In the present study, 60% of the students answered that the Moodle platform was the most used teaching material for monitoring the content, and 72% evaluated the quality of the content as being adequate. As a result, it is evidently important for the continuous insertion of support materials on virtual platforms, aiming at updating and improving their contents. With this, there is collaborative learning, in which the student and the teacher improve their skills, to extract the maximum of the functionalities of the virtual platforms. However, Santos et al.<sup>22</sup>, highlighted the need to organize activities to improve interactivity and collaboration between them.

In this study, it was possible to observe a good acceptance of virtual teaching by the students. This aspect is in line with what was found in a systematic review of e-learning in the teaching of

Dental Radiology<sup>23</sup>. The students reported positive points about the virtual platforms but they also reinforced that the combination of e-learning and the traditional teaching methodology added more value than just the virtual model. It becomes evident that the students themselves have the perception that traditional teaching is essential for the learning of Dental Radiology.

## 5 CONCLUSION

The virtual learning environment needs to act as a complementary source for teaching the interpretation of radiographic images, independently if used before or after the presential activities. The traditional teaching model is fundamental for the consolidation of the knowledge and skills needed in the discipline, while this virtual learning environment acts as a remarkable tool, with the potential to support the teaching and learning process. For this, it is necessary for mutual collaboration between the students and professors.

## RESUMO

### **Interpretação radiográfica de alterações no órgão dentário e tecido ósseo adjacente utilizando as ferramentas do ambiente virtual Moodle**

Os ambientes virtuais de aprendizagem (AVA) possuem inúmeras possibilidades de utilização de suas ferramentas e podem auxiliar nos processos de ensino e aprendizagem sobre a interpretação de imagens radiográficas. Este estudo teve como objetivo avaliar a utilização de um ambiente virtual de aprendizagem como material de apoio para alunos da disciplina de Radiologia Odontológica. Essa interpretação radiográfica foi realizada para contribuir com o conhecimento e treinamento das alterações no órgão dentário e tecido ósseo adjacente, visualizadas em radiografias periapicais e interproximais. As notas da prova virtual (via plataforma Moodle) e da prova de interpretação (em sala de aula) foram utilizadas para comparar

o Grupo Número 1 (alunos que realizaram a prova virtual antes da prova presencial) e o Grupo Número 2 (alunos que realizaram a prova virtual, após o teste em sala de aula). Observou-se que, em geral, a média da prova de interpretação foi superior à da prova virtual. Além disso, 66% dos alunos utilizaram a plataforma como principal recurso para acompanhar a disciplina, devido à possibilidade de revisão dos conteúdos e atividades. O ambiente virtual de aprendizagem pode ser considerado uma importante fonte complementar para o ensino da interpretação radiográfica. A plataforma Moodle atua como uma ferramenta notável, com potencial capacidade de apoiar o processo de ensino e aprendizagem. Para isso, é necessária a colaboração mútua entre alunos, Universidade e instituição de ensino para a constante utilização, manutenção e atualização do ambiente virtual.

**Descritores:** Aprendizagem. Moodle. Educação em Odontologia. Radiologia.

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