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DEVELOPMENT OF A MULTIMODAL TOOL TO SUPPORT TEACHING OF ROOT CANAL ANATOMY OF PRIMARY MOLARS: AN OBSERVATIONAL CROSS-SECTIONAL STUDY TO EVALUATE THE ACCEPTANCE OF UNDERGRADUATE STUDENTS

Maysa Lannes Duarte
Postgraduate studies of Department of Pediatric Dentistry and Orthodontics, School of Dentistry, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil
maysalannes@id.uff.br

Mariana Coutinho Sancas
Postgraduate studies of Department of Pediatric Dentistry and Orthodontics, School of Dentistry, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil
mari.sancas@gmail.com

Renata Perez Vianna Silva
Dentist of the Military Fire Brigade, Rio de Janeiro, RJ, Brazil
renataperez36@gmail.com

Aline de Almeida Neves
Professor of Department of Pediatric Dentistry and Orthodontics, School of Dentistry, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil
aline.dealmeidaneves@gmail.com

Laura Guimarães Primo
Professor of Department of Pediatric Dentistry and Orthodontics, School of Dentistry, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil
laura.primo1@gmail.com

Abstract

The study developed a multimodal imaging tool to support the teaching of root canal anatomy of primary molars and evaluated its acceptance by dentistry students. A cross-sectional study was developed and divided into two parts: creation of a video and elaboration of an electronic questionnaire to assess acceptance. Both were pre-tested for content and comprehension. Undergraduate dental students who were attending or had already attended a Pediatric Dentistry course were eligible. Data were collected from for two months and analyzed descriptively and comparatively (Wilcoxon test). A total of 135 students, mostly female (79.26%), from last or before last year (54.81%) at private institutions (86.67%), with an average age of 25.36±6.46 years old. Most of them (78.52%) were attending the Pediatric Dentistry course in the current semester, with online classes, synchronously (57.04%). Almost half (50.37%) thought they had reasonable knowledge about the anatomy of primary teeth before watching the video, and 59.26% did not seek extra information about the subject. Self-knowledge on the topic improved after watching the video ($p<0.01$). From those who answered the questionnaire completely (115), 99.13% considered the video relevant and 100% thought the information was clear. Video was well accepted by students while being important to help increase their knowledge.

Keywords

Blended Learning, Dental Education, Dental Students, Higher Education, Multimodal Imaging.

1. Introduction

Online teaching methods are being combined with traditional face-to-face education in high education institutes since the early 2000s. These methods, also known as “blended”, “hybrid”, and “inverted” learning, are categorized according to the integration between the methods (Rasheed et al., 2020). Blended learning can be defined as the application of more than one method, strategy, technique, or media in education (Sadeghi et al., 2014).

Intervention studies in education focus mainly on the comparison between the traditional and virtual education methods (Peroz et al., 2009; Ariana et al., 2016; Weber et al.,

2016; Soltanimehr et al., 2019; Slaven et al., 2019). However, such investigations, as applied to blended learning in dentistry are less common (Sadeghi et al., 2014; Mohammadzadeh et al., 2017). Distance education in its pure form, called e-learning, is not directly applicable to all subspecialties of Dentistry because the direct experience with patients cannot be completely replaced by virtual methods (Hattar et al., 2021). Videos are multimodal tools that can complement face-to-face activities or even act as the main part of some online learning modules (Dong and Goh, 2015). Furthermore, as they allow content repetition, they can provide additional support to students' cognitive and technical knowledge, at each individual own pace (Weber et al., 2016).

The scientific literature points out that the anatomy of primary teeth is a challenge for endodontic treatment, especially with the molars (Ahmed, 2013). Although methods of acquiring or retrieving information differ among individuals, dental students' learning style preferences indicate a preference for a multimodal modality (Al-Saud, 2013; Aldosari et al., 2018).

Thus, the present study aims to develop a multimodal imaging tool to support the teaching of the internal anatomy of primary molars and to assess, through a questionnaire, the acceptance of the video by undergraduate dentistry students in the state of Rio de Janeiro, Brazil. The null hypothesis of this study was that a multimodal tool, such as a video, would help students understand the characteristics and differences in the anatomy of primary molars.

2. Material and Methods

2.1. Study Design and Eligibility Criteria

This study was characterized as an observational cross-sectional study, carried out in four stages: 1) to investigate the presence and quality of online resources available on the websites of Public and Private Dental Schools relating to the anatomy of primary teeth, in the state of Rio de Janeiro (RJ), Brazil; 2) preparation of a video to support teaching the internal anatomy of primary molars; 3) elaboration of a questionnaire to evaluate the acceptance of the material; 4) implementation of the teaching tool and evaluation. This study was carried out following the recommendations of strengthening the Reporting of Observational Studies in Epidemiology (STROBE) (Von Elm et al., 2007). The research was approved by the research ethics committee.

2.2. Stage 1: Online Resources Available on the Websites of Higher Education Institutions (Heis) Relating to the Anatomy of Primary Teeth

To be included in this study, the HEI should have an active dentistry course, disclosed on the official website of the Ministry of Education and Culture (Ministério da Educação e Cultura – MEC). The HEIs were characterized by the following data collected from MEC´s website: name; administrative category (public or private); modality (face-to-face classes or e-learning), starting date of the course and location of the HEI. The official websites of the HEIs were accessed through Google® independently by two postgraduate students in Pediatric Dentistry and screened for the presence of information on internal anatomy of primary teeth. The Universities' intranet resources were not consulted.

The geographic locations of the HEIs were categorized according to the Brazilian Institute of Statistical Geography (Instituto Brasileiro de Geografia Estatística, 2020). The IBGE classification is divided into: Metropolis, Regional Capitals, Sub-Regional Centers, Zone Centers, or Local Centers – according to the differentiated offer of goods and services.

2.3. Stage 2: Video Preparation and Specialists' Evaluation

In this stage, an auxiliary multimodal teaching tool was developed, containing texts, narration, 3D animations and 2D images of primary teeth. The 3D images were obtained from previously extracted primary human molars representing each anatomical group, without root resorption that were produced by computerized microtomography (Skyscan 1173, Bruker, Kontich, Belgium). The video was less than five minutes long and was prepared using a free website (https://www.powtoon.com, San Francisco, California, USA) providing explanations about anatomical characteristics of primary molars, such as number of roots and canals in each group of teeth.

After elaboration, the video was sent individually by email to 14 specialists in Pediatric Dentistry for content checking and to one education professional to assess the language, captions, narration, illustrations, and ease of comprehension. The evaluators were instructed to report their observations and were encouraged to make suggestions. One week after sending the video, a meeting was held enabling all evaluators to clarify any doubts and make suggestions. The suggestions were discussed by the researchers and, when agreed, were accepted. The video can be accessed through the following link: https://youtu.be/_H99aL5z7M4.

2.4. Stage 3: Questionnaire Elaboration and Evaluation by Specialists

In the meantime, a self-applied electronic questionnaire containing 22 questions, divided into two blocks, was elaborated. Block 1 was intended for students to answer before watching the video, aiming to characterize the sample, investigate the study profile, their experience with the Pediatric Dentistry course and self-judgment about the knowledge of the anatomy of primary molars. Block 2 contained the video, and the questions were used to assess the acceptance of the tool in terms of the clarity of the information. The questions used in the questionnaire are detailed in Table 1.

The last three questions in Block 2 assessed to what extent the video helped to transmit its content, if the viewers considered any academic benefits of it and if tools like this should be used in Pediatric Dentistry courses. The assessment was made using a scale from 0 to 100, where 0 represented little and 100 very much. The gradation from 0 to 100 was pre-established by the Survey Monkey® online questionnaire tool.

The online questionnaire was sent individually to the same experts previously mentioned, for their evaluation. The adaptations deemed pertinent by the researchers were accepted and a final version of the questionnaire was created.

2.5. Stage 4: Acceptance of the Multimodal Teaching Tool

Dental students from the state of Rio de Janeiro, over 18 years of age, who were attending or who had already attended the Pediatric Dentistry course at the time of the research, were eligible to participate in this stage of the study. Individuals who had already graduated or had not started the Pediatric Dentistry course were not eligible. Consent for voluntary participation in the research was obtained digitally. Students that were not eligible and answered the questionnaire incompletely or those who refused consent were also excluded.

A convenience sample of undergraduate dental students from the state of Rio de Janeiro was adopted. Initially, the headmasters of the Pediatric Dentistry courses at each HEI were asked to disclose the research link containing the video and the questionnaire to their students by sharing the link by email or WhatsApp Inc® (WhatsApp Inc. Menlo Park, California, USA). Later, the same link was published on the social network Instagram® of the HEI (Menlo Park, California, USA). Researchers did not contact the students directly at any stage of the study. Data were collected from April to May 2021.

The material was made available for the students through the online platform Survey Monkey® (https://pt.surveymonkey.com, San Francisco, California, USA) in a single link. The email addresses of the participants were recorded to prevent the questionnaire from being answered more than once. However, during data tabulation, all email addresses were omitted to maintain the sample confidentiality. There was no time limit for answering the questionnaire, which reduces the chance of inappropriate or rushed responses.

2.6. Statistical Analysis

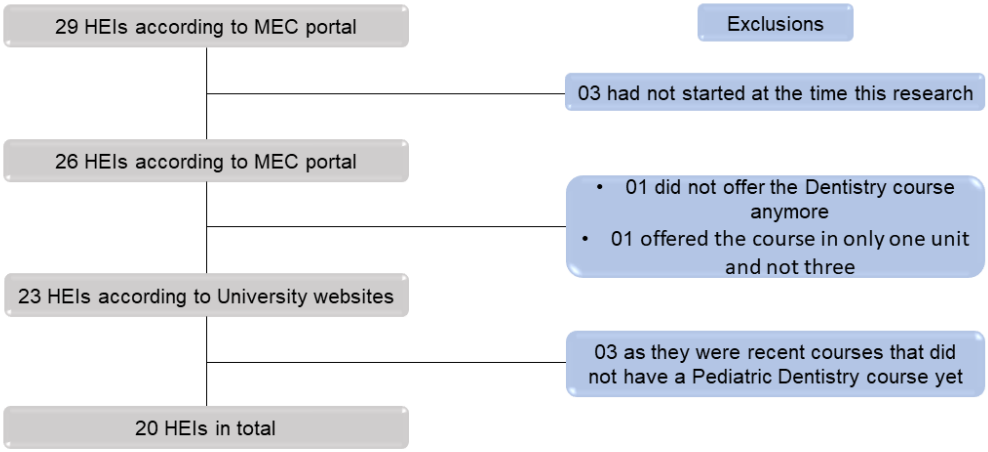
All responses were included in the analyses. Thus, students who responded only to Block 1 (before the video) were also considered to characterize the sample, but their questionnaires were considered incomplete.

All data collected in stages 1 and 4 were tabulated in Microsoft Excel® (Microsoft Corporation, Redmond, WA, USA) for descriptive analysis. To evaluate students' self-judgment about their knowledge on anatomy of root canals of primary molars before and after the video, the data were initially tested for normality, followed by a comparative analysis using the Wilcoxon test (BioEstat v.5.0, Instituto Mamirauá, Manaus).

3. Results

According to MEC, there are 29 HEIs with active dentistry courses in the state of Rio de Janeiro. However, three of these had not started Pediatric Dentistry course at the time this research was conducted. After consulting the official websites of each HEIs, one was not offering the Dentistry anymore and another offered the course in only one unit and not three, as shown on the MEC website. After contacting staff members, other three HEIs were excluded, as they were recent courses that did not have a Pediatric Dentistry course yet; thus, there were 20 courses remaining for this study (Figure 1). Of these, 16 are categorized as private and 4 as public. The courses were taught only in person/face-to-face classes, according to MEC´s website. The HEIs are in 13 cities: 4 in metropolis, 3 in regional capitals, 5 in sub-regional centers and 1 in a local center. Public information on the internal anatomy of primary teeth was not found on any of the websites (accessed: October 2020).

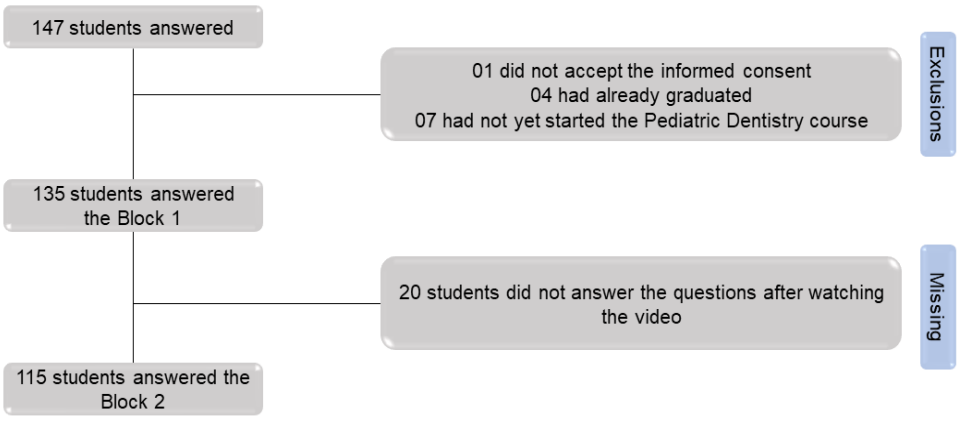
Figure 1: *Flowchart Describing the Exclusions of Higher Education Institutions (HEIS).*



Source: Self/Authors' Own Illustration

One hundred and forty-seven students answered the questionnaire. Of these, 12 were excluded since they did not accept the informed consent (n=1), had already graduated (n=4) or had not yet started the Pediatric Dentistry course (n=7) (Figure 2). Finally, the sample consisted of 135 students that answered Block 1, mostly female (n=107; 79.26%) with a mean age of 25.4 ± 6.5 years old (most frequent age = 23). One hundred and seventeen (86.67%) students were enrolled in private HEIs, and 74 (54.81%) were junior or senior years (last or before last year). Students from 13 HEIs located in eight different cities answered the questionnaire. The answers were obtained from cities of four IBGE classifications, with the largest number coming from metropolitan cities (n=57; 42.22%) (Table 1).

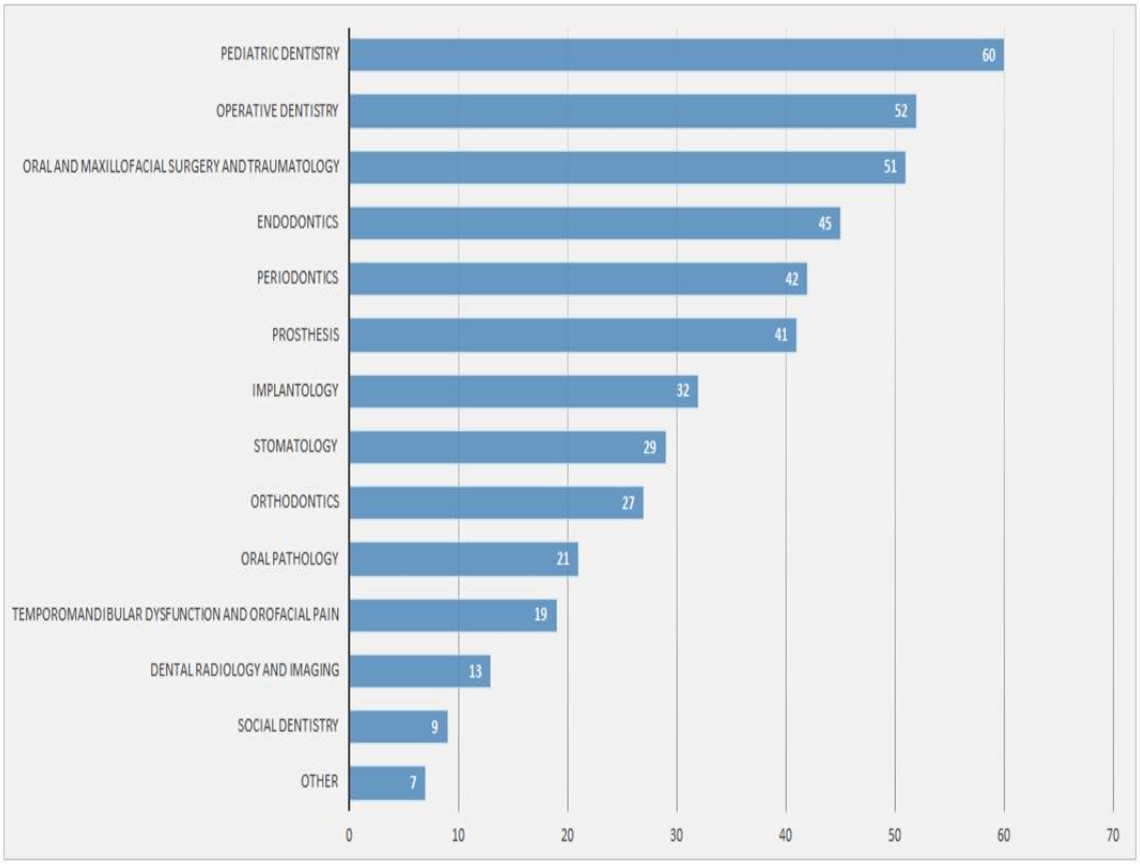
Figure 2: *Flowchart Describing the Process of Obtaining the Sample.*



Source: Self/Authors' Own Illustration

The subjects in which the students were most interest in were Pediatric Dentistry (n=60; 44.44%), followed by Operative Dentistry (n=52; 38.52%), and Oral and Maxillofacial Surgery / Traumatology (n=51; 37.78%) (Figure 3). One hundred and six (78.52%) students were studying Pediatric Dentistry in the semester in which the research was conducted, most with synchronous online classes (n=77; 57.04%) (Table 1).

Figure 3: *Disciplines that aroused the greatest interest among the students.*



Source: Self/Authors' Own Illustration

Sixty-eight (50.37%) students consider that they had "reasonable" knowledge concerning the anatomy of primary teeth before watching the video and only 3 students (2.22%) considered they had good knowledge on the subject (Table 2). Eighty-nine (65.93%) students had never sought extra information on the subject, while among those who did, 31 (22.96%) used books as information sources. Most respondents search for extra content related to Dentistry on the Internet on an average of three (n=66; 48.89%) or five (n=32; 23.70%) times a week, mainly looking for scientific articles (n=99; 73.33%) (Table 1).

Table 1: Sample Characterization (n=135)

Variables	n (%)
Gender	
Female	107 (79.26)
Male	28 (20.74)
I prefer not to declare	0 (0.0)
Age	
18 - 24	87 (64.45)
25 - 40	43 (31.85)
41 - 56	4 (2.96)
57 - 75	1 (0.74)
Institution	
Public	18 (13.33)
Private	117 (86.67)
IBGE classification of cities of HEIs	
Metropolis	57 (42.22)
Regional Capitals	32 (23.70)
Sub-Regional Centers	38 (28.15)
Local Centers	8 (5.92)
Present semester	
6^{th}	11 (8.15)
7^{th}	74 (54.81)
8th	30 (22.22)
9th	14 (10.37)
10th	6 (4.44)
Which semester did you attended the pediatric dentistry course?	
I am studying this semester	106 (78.52)
I attended last semester	11 (8.15)
I attended the semester before	11 (8.15)
More than a year ago (2019 or earlier)	7 (5.19)
How were the theoretical classes in pediatric dentistry taught?	
All classes were online synchronously	77 (57.04)
All classes were online asynchronously	3 (2.22)
All classes were online part synchronously and part asynchronously	11 (8.15)
Synchronously online and face-to-face	30 (22.22)
Part online asynchronously and part face-to-face	2 (1.48)
All classes were face-to-face	12 (8.89)
Have you ever sought extra information on the internal anatomy of primary teeth?	
No	89 (65.93)

Yes	46 (34.07)
Which medium(s) did you use to seek information on the anatomy of primary teeth? *	
I didn't look for extra information on the subject	80 (59.26)
In "lives" of teachers and online congresses on the subject	16 (11.85)
In social media (Instagram, Facebook®, YouTube®, blogs)	23 (17.04)
In modules, courses, and lectures of face-to-face congresses	1 (0.74)
In scientific journals or articles on the subject	22 (16.30)
In books on the subject	31 (22.96)
How often do you look for extra content about Dentistry?	
Never (not once)	2 (1.48)
Rarely (on average, once a month)	5 (3.70)
Infrequently (on average, 3 times a month)	19 (14.07)
With reasonable frequency (on average, 3 times a week)	66 (48.89)
Very often (on average, 5 times a week)	32 (23.70)
Always (every day)	11 (8.15)
Which format of extra content related to Dentistry do you like the most? *	
Scientific articles	99 (73.33)
Written materials from dentistry sites or social networks not connected to universities	61 (45.19)
Written articles from university dentistry sites or social networks	62 (45.93)
Videos on social networks	64 (47.41)
Videos on YouTube®	66 (48.89)
Videos on university websites	20 (14.81)
I don't usually search for content on the internet	1 (0.74)

* Respondents could choose more than one option.

Source: Self/Authors' Own Illustration

Twenty students did not answer the questions after watching the video (Block 2). Thus, only 115 (85.18%) students answered the questionnaire completely. Of these, 40% (n=46) reported they had "good" knowledge concerning the anatomy of primary teeth after watching the video. Nineteen respondents (16.52%) said their knowledge was "great" after watching the video. The students' self-judgment was statistically better after the video (p=0.0001) (Table 2).

Table 2: Self-Judgment of the Student Concerning their Knowledge of the Anatomy of Primary Teeth Before and after Watching the Video.

	Before video n=135 (%)	After video n=115 (%)	Significance*
Excellent	3 (2.22)	19 (16.52)	p=0.0001
Well	40 (29.63)	46 (40.00)	

Reasonable	68 (50.37)	36 (31.30)
Insufficient	22 (16.30)	13 (11.30)
Nonexistent	2 (1.48)	1 (0.87)

*Wilcoxon test.

Most respondents (n=114; 99.13%) considered the content as relevant and 115 (100%) that the information was explained clearly. On a scale from 0 to 100, most believed that videos helped to transmit content on the subject, that they would have better academic results if videos were offered in the Pediatric Dentistry course, and that such videos should be used as auxiliary teaching tools (Table 3).

Table 3: Students' Perceptions of the Video (n = 115).

Do you think the video content was relevant to increase your knowledge?	
No	1 (0.87)
Yes	114 (99.13)
Do you think the explanations of the video were clear?	
No	0 (0.00)
Yes	115 (100)
On a scale of 0 to 100, how much do you believe that texts associated with images, such as the video you watched, help in transmitting the content of internal anatomy of primary teeth?	
Media	95.67
Standard Deviation	8.54
Mode	100
On a scale of 0 to 100, how much do you believe you would have better academic results if theoretical content and complementary videos like the one you just watched were offered in the Pediatric Dentistry discipline?	
Media	94.16
Standard Deviation	14.12
Mode	100
On a scale of 0 to 100, how much do you believe that the use of audiovisual resources, such as the video you watched, should be used as auxiliary teaching tools by teachers?	
Media	95.89
Standard Deviation	12.55
Mode	100

Source: Self/Authors' Own Illustration

4. Discussion

The video developed was well accepted by the students, who evaluated the information as relevant and clear. Moreover, they believed that the tool could help to transmit the subject in Pediatric Dentistry courses. Similarly, previous research also showed good acceptability of recorded video contents among students, who pointed out the possibility of accessing the content at different times as an extra advantage, and not just during the lecturer's presentation (Suner et al., 2019). In the present study, reconstructions of human primary teeth in 3D and their animations brought the video closer to the reality that will be found by the future professional in the clinic. Computerized microtomography was chosen because the images acquired were able to describe the root canal system and its ramifications accurately (Mazzi-Chaves et al., 2020).

This auxiliary tool also intended to fill in the absence of similar materials found on the websites of the universities surveyed during stage 1 of this study. As previously reported, the availability of videos may be restricted to private platforms at universities, on the so-called intranet (Goset and Espinoza, 2013) and, therefore, the lack of available content on the subject should be interpreted with caution. Since the video produced on this study presents a generic content of common interest to all dentistry students, regardless of their institution, it is understood that its wide dissemination would be a good practice.

The sample in this study was mainly composed of female students, which agrees with previous studies carried out in several countries (Schlenz et al., 2020; Aragão et al., 2021; Hattar et al., 2021) and may be characteristic of Dentistry courses. In addition, the larger number of private educational institutions is characteristic of the country where this research was conducted (Aragão et al., 2021). In addition, the present study was designed and carried out during the COVID-19 pandemic, when students were socially distancing, with reduced clinical practice, and attending to online classes. In this scenario, it became even more relevant to create tools that would bring them closer to clinical reality. The investigation of the acceptability of the tool was fully justified considering that these students could be overloaded with online activities.

Another aspect related to the sample was the heterogeneity of the students' age. If categorized into generations, the sample contains students from the Baby Boomer generations (born between 1946 and 1964), Generation X (born between 1965 and 1980), Millennials (born between 1981 to 1996) and generation Z (born between 1997 and 2012) (Colby and Ortman, 2014; Dimock, 2019). Most respondents were from the generation Z, characterized by individuals with

relatively short attention spans and a need for instant feedback (Roberts et al., 2012). They are considered "digital natives", i.e., the only generation that does not need to adapt to new digital technologies since they were exposed to them from birth, and are active users (Pew Research Center, 2014). The use of technology as a learning tool can be the key to improve the engagement of these students (Hung et al., 2010). Short videos like the one developed here can contribute to a greater commitment of undergraduate students. Extensive questionnaires, on the other hand, can be an obstacle, generating incomplete responses from parts of the sample. In addition, during the period of the pandemic, people participated in many surveys that used electronic questionnaires, which may have left them exhausted, reflecting on the number of participants.

Despite being a challenge for teachers, the diversity of ages of the target audience cannot prevent the transmission of information, since higher education aims to serve all age groups in an equally didactic way. In this sense, blended learning becomes a relevant tactic for higher education. This approach allows the combination of different teaching methods in a pedagogically balanced way, such as the association of traditional classroom classes and e-learning methods (Schlegel et al., 2021). The present study is proposing a combination of teaching methods rather than the replacement of the traditional classes, introducing an auxiliary tool to process and recover the information already given.

Most students were in the junior or senior years of their university studies and all of them had already had their first contact with this specific subject. Although, self-judgment on the matter was reasonably good before they saw the video, after watching it, most students judged their knowledge to be good, noting that the tool could improve student self-assessment. It has previously been shown that students exposed to a supplementary video demonstrating the theoretical class perform significantly better than without the use of such didactic resources (Aragon and Zibrowski, 2008).

Students in their last year felt more comfortable with e-learning than those in the first years (Hattar et al., 2021), proving it to be an important tool to help reinforce subjects already covered. The proposal of continuous learning, however, is not limited to students who are completing their graduation. The association of lectures and videos in pre-clinical subjects showed an increase in student performance compared to students who participated only in traditional lecture classes, considering the experience useful and advantageous (Goset and Espinoza, 2013;

Shigli et al., 2017; Amrithaa et al., 2020). Likewise, the present students considered the video useful for learning the proposed theme.

Although online resources have been used since the early 2000s (Rasheed et al., 2020), a study at Justus Liebig University (Germany), reported that many dental professors had never worked with online teaching formats before the COVID-19 pandemic. Almost all students considered this model a good option (Schlenz et al., 2020). The tool developed in this study can be used in other disciplines, such as endodontics of permanent teeth, radiology, or operative dentistry, and with the advantage of minimizing the use of human material (extracted teeth) in pre-clinical classes. However, we emphasize that Dentistry is an eminently clinical career, and thus it is opportune to discuss the teaching of Dentistry in digital format.

5. Conclusion

The video developed as an auxiliary teaching tool to support the teaching of the internal anatomy of primary molars was well accepted by undergraduate dental students, who rated the information as being relevant and clear. Students believe that the tool helped in the transmission of information about the subject, and that it was useful in their Pediatric Dentistry courses.

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