Analysis of the learning experience of a hybrid model in Orthodontics in the context of the COVID-19 pandemic

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Abstract The aim of this study was to analyze the learning experience of students in the face of a hybrid teaching model developed and applied during the academic semesters 2020.2 (pre-vaccination), 2021.1 (during vaccination) and 2021.2 (post-vaccination) during the COVID-19 pandemic. For the analysis, qualitative and quantitative data were collected throughout the semesters using a questionnaire with sociodemographic, technology/education, pandemic, and topic perception questions. Summative data was also collected from activity grades, the theory test, and the final average. Results were analyzed using the RE-AIM instrument, which assesses the domains of reach, effectiveness, adoption, implementation, and maintenance. A total of 102 students participated in this study, 74 females and 28 males, with a mean age of 23.4 years (±2.3). The majority of students had a WiFi connection (95.1%) and accessed the online classes using laptop (69.6%). According to the RE-AIM domains, students found the course effective (97%) and felt prepared for their professional future (70.6%). There was no difference in the average scores of the classes, all with an average above 80% (p>0.05). Regarding the different moments of the pandemic, even with increased anxiety during vaccination, there was no change in performance and perception of the format of the course. The teaching method demonstrated to be effective and was positively perceived by the students at the time of the COVID-19 pandemic, regardless of the stage they were in, and could be an alternative for subjects wishing to integrate educational technologies into the curriculum.
Descriptors: Educational Technology. Orthodontics. COVID-19. Education, Dental.

Análisis de la experiencia de aprendizaje de un modelo híbrido en Ortodoncia en el contexto de la pandemia COVID-19
Resumen El objetivo de este estudio fue analizar la experiencia de aprendizaje de los estudiantes frente a un modelo de enseñanza híbrido desarrollado y aplicado a lo largo de los períodos académicos 2020.2 (antes de la vacunación), 2021.1 (durante la vacunación) y 2021.2 (post vacunación) durante la pandemia de COVID-19. Para el análisis se recolectaron datos cualitativos y cuantitativos a lo largo de los semestres, mediante un cuestionario con preguntas sociodemográficas, tecnología/educación, pandemia y percepción de la disciplina. También se recogieron datos sumativos de notas de actividades, prueba teórica y media final. Los resultados fueron analizados mediante el instrumento RE-AIM, evaluando los ámbitos de alcance, efectividad, adopción, implementación y mantenimiento. Participaron de este estudio 102 estudiantes, 74 mujeres y 28 hombres, con una edad promedio de 23,4 años (±2,3). La mayoría de los estudiantes disponían de conexión WiFi (95,1%) y accedían a clases a través del ordenador portátil (69,6%). Según los dominios RE-AIM, los estudiantes consideraron efectiva la asignatura (97%) y se sintieron preparados para su futuro profesional (70,6%). No hubo diferencia en los puntajes promedio de las clases, todas con un promedio superior al 80% (p>0,05). En cuanto a los diferentes momentos de la pandemia, incluso con mayor ansiedad durante la vacunación, no hubo cambios en el desempeño y percepción sobre el formato de la disciplina. El método de enseñanza aplicado demostró ser eficaz y fue percibido positivamente por los estudiantes en el momento de la pandemia COVID-19, independientemente de la fase en la que se encontraban, y podría ser una alternativa para asignaturas que deseen integrar las tecnologías educativas al currículo.
Descriptores: Tecnología Educacional. Ortodoncia. COVID-19. Educación en Odontología,

Análise da experiência de aprendizagem de um modelo híbrido em Ortodontia

no contexto da pandemia da COVID-19

Resumo O objetivo desse estudo foi analisar a experiência de aprendizagem dos alunos frente a um modelo de ensino híbrido desenvolvido e aplicado ao longo dos períodos letivos de 2020.2 (antes da vacinação), 2021.1 (durante a vacinação) e 2021.2 (pós-vacinação) durante a pandemia da COVID-19. Para a análise foram coletados dados qualitativos e quantitativos ao longo dos semestres, utilizando um questionário com questões sociodemográficas, tecnologia/educação, pandemia e percepção da disciplina. Também foram coletados dados somativos a partir das notas de atividades, prova teórica e média final. Os resultados foram analisados a partir do instrumento RE-AIM, avaliando as esferas de alcance, efetividade, adoção, implementação e manutenção. Participaram desse estudo 102 alunos, sendo 74 do sexo feminino e 28 do sexo masculino, com média de idade de 23,4 anos (±2,3). A maioria dos estudantes tinham conexão via *WiFi* (95,1%) e acessavam as aulas por *notebook* (69,6%). De acordo com os domínios do RE-AIM os alunos consideraram a disciplina eficaz (97%) e se sentiram preparados para o futuro profissional (70,6%). Não houve diferença na média dos escores das notas das turmas, todas com média acima de 80% (p>0,05). Quanto aos diferentes momentos da pandemia, mesmo com aumento da ansiedade durante a vacinação, não houve uma mudança no desempenho e percepção sobre o formato da disciplina. O método de ensino aplicado mostrou-se efetivo e foi percebido positivamente pelos estudantes no momento da pandemia da COVID-19, independentemente da fase em que se encontravam, podendo ser uma alternativa para disciplinas que desejem integrar tecnologias educacionais no currículo.

Descritores: Tecnologia Educacional. Ortodontia. COVID-19. Educação em Odontologia.

INTRODUCTION

The process of training Dental Surgeons (DS) must comply with the new guidelines of the Brazilian National Curriculum (DCN), established in Resolution No. 3, published by the Ministry of Education (MEC) in 2021[1]. From this perspective, it has become necessary to associate socio-environmental changes, the inclusion of the Internet in everyday life, changes in the profile of new generations and the management of the COVID-19 pandemic. As a result, it has become imperative to rethink the teaching-learning processes in the undergraduate dentistry course in order to meet the demands of the new moment and the job market[2].

In response to this need, various online teaching formats have been applied[3-4]. This type of approach involves the incorporation of technology into the teaching-learning process, making methodological design indispensable for building the flow of a course, as well as its learning objects and assessment[5-6]. The inclusion of technology-mediated teaching in dentistry is an alternative in the hybrid model, since it cannot replace clinical practice[7]. In the context imposed by the pandemic and with the pedagogical and technological resources available, a hybrid methodology based on active methods was developed for the orthodontics course at the School of Dentistry of the State University of Rio de Janeiro (UERJ). The subject, previously taught entirely in person with lectures, was now taught using a flipped learning model, in which the pedagogical approach is based on presenting basic material to students before class, and class time is used to deepen understanding through discussion between classmates and teachers[8].

However, in order to evaluate the effectiveness of an educational proposal, it is necessary to go beyond students' perceptions. To this end, there are a number of tools used for the reflective analysis of educational planning, such as Item Response Theory (IRT), the Kirkpatrick model, Context - Input - Process and Product Evaluation (CIPP), Realistic Evolution, Layered Analysis and the RE-AIM model (Reach, Efficacy, Adoption, Implementation and Maintenance)[2]. All of these tools allow for a reflective analysis of pedagogical planning, but according to a study published in 2021, in the field of health education, the RE-AIM framework stands out because it focuses on the entire learning process and not just on perceptions or summative grade data in isolation[9].

In this context, this study aimed to analyze the students' learning experience in the face of the technology-mediated teaching model applied to the discipline of Orthodontics at the UERJ School of Dentistry during the academic semesters taught at different times of the COVID-19 pandemic, through quantitative and qualitative analysis based on the RE-AIM framework.

METHODS

This study included 102 students enrolled in the Orthodontics Course of the School of Dentistry of the State University of Rio de Janeiro, Rio de Janeiro, Brazil, during the COVID-19 pandemic (semesters 2020.2, 2021.1 and 2021.2). The research project was previously approved by the Research Ethics Committee (CAAE: 41955820.1.0000.5259).

Course Planning

The course was designed using the hybrid teaching model, where the entire theoretical part was taught online in thematic modules, with asynchronous and synchronous activities through the institutional Virtual Learning Environment (VLE). The theoretical part was designed according to the flipped learning model, in which each thematic module was available for one week and consisted of video lessons previously recorded by the subject teachers at intervals of 30 to 50 minutes; forum activities based on the problem-based learning methodology, in which students had contact with a problem question related to the module topic and had to answer it individually. After submitting their answers, students had access to their classmates' answers and could change their answers if they felt it necessary, with a reduction in their score for the activity. The goal of this dynamic was to use this interaction as an opportunity to learn from mistakes, according to the principles of the learning from failure methodology. In addition, an objective question-answer activity with three questions was provided for each module to assess the application of the content taught. This was followed by a synchronous session between students and teachers for questions and discussions. At the end of the five modules, students were given a theoretical assessment with objective questions covering all the content.

The practical part was taught face-to-face in the laboratory. The same model was used at all times during the pandemic. The practical activities followed all university biosafety recommendations.

The new course design consisted of five modules, each containing three expository video lessons, a forum with a formative question based on solving a clinical case (problem-based learning methodology), and three quizzes consisting of summative questions related to the lesson taught. Students had one week to complete the activities in each module, followed by a synchronous meeting with faculty for discussion, questions, and sharing.

The summative scores for the theoretical questions (quizzes, forums, and written tests) were obtained and weighted into scores from 0 to 10 points, corrected, and made available on the virtual platform itself on an individual basis.

Data Collection and RE-AIM Questionnaire

The following information obtained during the course was used for data collection and analysis: summative grades from forum activities, quizzes, and the theory test, and scores from a semi-structured instrument (questionnaire). Each piece of data was interpreted in the corresponding domain of the RE-AIM framework.

The questionnaire used was based on previously validated questions from other questionnaires and consisted of 31 questions, of which 26 were objective and five discursive, distributed in five domains that included questions related to sociodemographic data, education and technology; perception of the discipline and the COVID-19 pandemic. Each item related to student perception followed the 5-point Likert scale with the following response options: totally disagree; disagree; neither agree nor disagree; agree or totally agree[10]. This instrument was structured using Google Forms (Google, California, USA) and was administered on the day of the theory test, with the link to the answers made available to the students, with anonymous and voluntary participation.

All the data were tabulated in a unified spreadsheet (Microsoft® 365 Excel®, saved in .xls format), derived from the data exported from GoogleForms and the virtual learning environment (MOODLE). Once the data were collected, a descriptive and statistical analysis was performed, relating each item to its corresponding RE-AIM domain.

RE-AIM Domain 1 (Reach)

This included the number of participants in the sample, student attendance data collected from each student's attendance in each of the synchronous classes over the three semesters, and sociodemographic information obtained from the script based on the study by Benedetti et al. (2014)[11], which consisted of questions about age, gender, marital status, type of device used to attend class, type of internet access, previous experience with online classes, and ideal duration of online classes.

RE-AIM Domain 2 (Effectiveness)

This domain assesses the results achieved by the teaching methodology used by evaluating quantitative and qualitative metrics[11].

For the quantitative metric, the scores of the quizzes, forums and theoretical exam - with multiple choice activities - were tabulated. Each of the five modules had a score of 2.5 points (1.5 for the quizzes and 1.0 for the forum), with a total of 10 points at the end of the 4 modules as the maximum score. To calculate the theoretical average, the sum of the module grades and the theoretical test grade was averaged and divided by two. To assess the effectiveness of the course, the average of the forums, quizzes, and theory test was taken separately for the three classes that participated in the research.

To obtain the qualitative measures, students' perceptions of the course were documented by collecting responses to the following questions: the effectiveness of the course and its teaching aids; the difficulty of attending online classes; whether concentration was affected by the time experienced; whether distance activities affected learning; whether students felt prepared for the future; and whether they were satisfied with the quality of the course.

RE-AIM Domain 3 (Adoption)

Data on the final average of all classes and the percentage of students who passed the theoretical part of the course with a score above 70% were included. In the case of this study, the students' own perceptions were also taken into account through a qualitative metric of questions that verified whether the activities were clear and fair; what was the greatest difficulty encountered when participating in online classes; which technology-mediated teaching modality was preferred; whether they felt more anxiety and impaired attention during the period of the COVID-19 pandemic.

RE-AIM Domain 4 (Implementation)

Accessibility, time, human resources, educational technology expertise required, and cost to implement the pedagogical proposal were considered. The aim was to answer the following questions, adapted from Benedetti et al. (2014)[11]: habit of watching pre-recorded educational material, time spent watching the videos, whether the course was well organized, number of accesses to the videos, and whether the course stimulated learning.

RE-AIM Domain 5 (Maintenance)

In the maintenance domain, the aim was to evaluate the long-term learning process, possible improvements in the way the methodology is applied, the cost-benefit of the program and its possible institutionalization. In this sense, the study data were collected over different periods, maintaining the pedagogical model, in order to compare the results between the three semesters (three classes). The following open-ended discursive questions were used "How could this course be improved?" and "What did you like best about this course?".

Statistical analysis

Data were analyzed using GraphPad Prism version 10.0 (GraphPad Software Inc., San Diego, USA) and R Statistical Package version 4 (R Foundation for Statistical Computing, Vienna, Austria). First, descriptive statistics were performed using measures of absolute and relative frequency, mean and standard deviation ($\pm$sd). The dependence of the distribution between categorical variables was assessed using the chi-squared or Fisher's exact test. The Kruskal-Wallis

test was used to compare the summative scores between the three periods. The significance level was set at 5% (p<0.05). The results were presented in tables and bar graphs.

RESULTS

RE-AIM Domain 1 (Reach)

A total of 102 students (72.5% female and 27.5% male) with a mean age of 23.4 ± 2.3 years were included in this study. Of these, 46 students took the course in the second semester of 2020 (period when the pandemic started, without COVID-19 vaccine), 23 students in the first semester of 2021 (period with COVID-19 vaccine) and 33 students in the second semester of 2021 (period with COVID-19 vaccine and decrease in mortality curve). It was observed that most of the sample was single (95.1%), had no children (98%), and 95.1% accessed classes via a WiFi connection (95.1%). In addition, just over 50% of the students reported having only one computer at home, and 69.6% used laptops to access the subject's online classes. The majority of students reported that they rarely (41.2%) or only sometimes (29.4%) attended online classes prior to the COVID-19 pandemic. The ideal time for online classes reported most frequently in the sample was 30 minutes (52.9%) (Table 1).

Figure 1 compares the distribution of the option for ideal online class time according to the responses obtained in each academic semester. There were statistically significant differences in the choice of ideal time for online classes between the different academic semesters (p <0.001). The majority of students in class 2020.2 said that the ideal time was 30 minutes (91.3%), while in classes 2021.1 and 2021.2 the times 45 minutes and 1 hour had the highest frequency.

Table 1. Distribution of general characterization variables and Internet access patterns in the evaluated sample (RE-AIM Reach Domain).

Variables	mean	±sd	n	%
Sex				
Male			28	27.5
Female			74	72.5
Age (in years)	23.4	±2.3		
Age group				
20 to 24 years			80	78.4
25 years or more			22	21.6
Marital status				
Single			97	95.1
Married			5	4.9
Child(ren)				
Yes			2	2.0
No			100	98.0
Number of computers at home				
None			3	2.9
One			56	54.9
Two			27	26.5
Three			10	9.8
More than three			6	5.9
Type of connection most used at home				
3G			1	1.0
4G			4	3.9
Wi-Fi			97	95.1
Device to access online classes				
Desktop			12	11.8
Laptop			71	69.6
Cell phone			15	14.7
iPad/ Tablet			4	3.9

continues

continuation

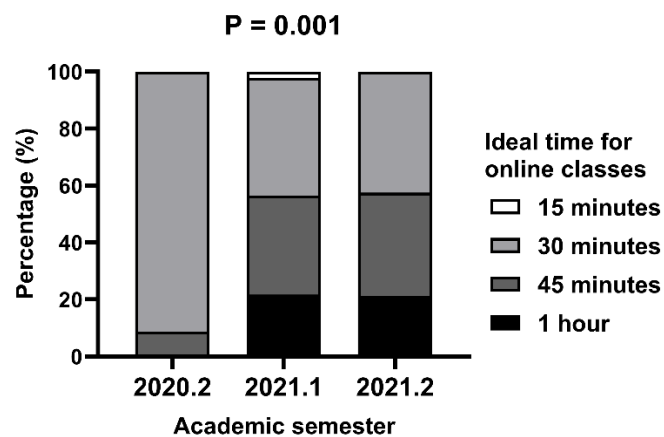|		
Attendance at online classes before the COVID-19 pandemic		
Never	18	17.6
Rarely	42	41.2
Sometimes	30	29.4
Often	11	10.8
Always	1	1.0
Ideal time for online classes		
15 minutes	1	1.0
30 minutes	54	52.9
45 minutes	30	29.4
1 hour	17	16.7

±sd = standard deviation.

Figure 1. Distribution of ideal time for online classes in different academic semesters (RE-AIM Reach Domain).

RE-AIM Domain 2 (Effectiveness)

Table 2 presents data on variables related to experience with distance education. In the sample, the majority of students reported that they had rarely (41.2%) or sometimes (29.4%) participated in online courses before the COVID-19 pandemic. Low and moderate difficulties in taking online courses were the most common reports (43.1% and 32.4%). The most common difficulty was Internet problems (44.1%). It should also be noted that 10.8% of the sample reported no difficulties with technology-mediated instruction. It was observed that 43.1% of the students reported that online classes somewhat reduced their learning. Most of the sample agreed that the COVID-19 pandemic affected concentration (44.1% totally agree and 38.2% agree). On the other hand, the method used was considered by the students to be effective in learning (totally agree 73.5% and agree 23.5%). In addition, it was observed that 68.6% of the students totally agreed that they were satisfied overall with the quality of the subject and 70.6% felt prepared or very prepared for their professional future.

Figure 2 shows the comparison of the variables analyzed in the Effectiveness domain between the classes of the 2020.2, 2021.2 and 2021.2 semesters. The average scores for the evaluation between the classes did not show significant differences (p >0.05). There were no statistically significant differences in the variables difficulties in attending online classes ($p = 0.356$), the extent to which online classes negatively affected learning ($p = 0.309$), difficulty concentrating with online classes ($p = 0.382$), the perception that the teaching method was effective in learning ($p = 0.328$), overall satisfaction with the subject ($p = 0.493$) and the feeling of being prepared for the future ($p = 0.451$).

Table 2. Distribution of the variables related to the distance learning (RE-AIM Effectiveness Domain).

| Variables	n	%
Have you had any difficulty watching online classes?		
No difficulty	15	14.7
Low difficulty	44	43.1
Moderate difficulty	33	32.4
Great difficulty	10	9.8
To what extent do you think distance learning activities affect your learning?		
Increased a lot	19	18.6
Increased a little	21	20.6
Has not changed	14	13.7
Decreased a little	44	43.1
Decreased a lot	4	3.9
My concentration has been affected by the current period		
Totally agree	45	44.1
Agree	39	38.2
Neither agree nor disagree	12	11.8
Disagree	5	4.9
Totally disagree	1	1.0
The teaching method was effective for learning		
Totally agree	75	73.5
Agree	24	23.5
Neither agree nor disagree	3	2.9
Disagree	-	-
Totally disagree	-	-
Overall, I am satisfied with the quality of the course		
Totally agree	70	68.6
Agree	30	29.4
Neither agree nor disagree	1	1.0
Disagree	1	1.0
Totally disagree	-	-
Based on your coursework, do you feel prepared for the future with regard to orthodontics?		
Very prepared	21	20.6
Prepared	51	50.0
Not very prepared	17	16.7
Neither prepared nor unprepared	8	7.8
Unprepared	5	4.9
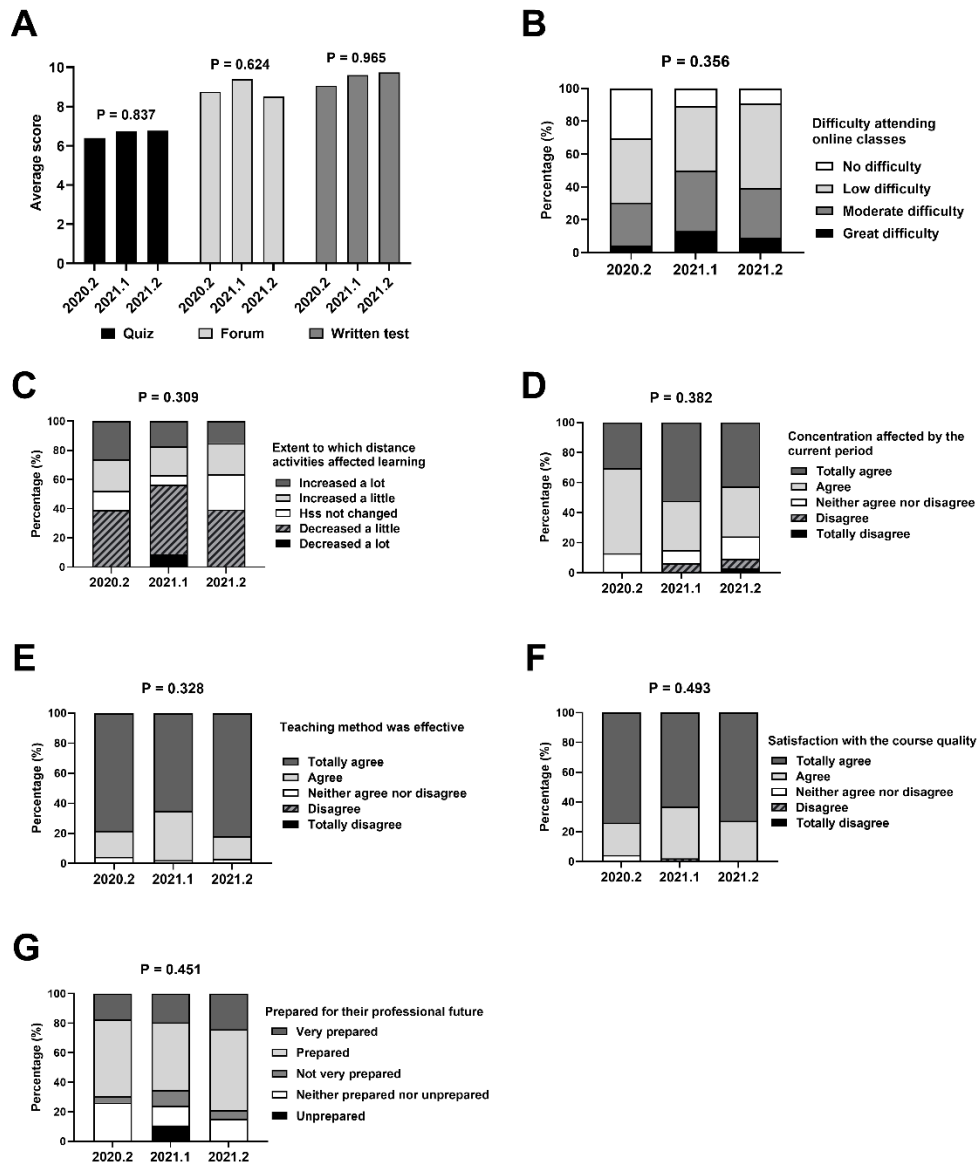
Figure 2. Comparative analysis of mean scores of summative evaluations (A), difficulty in attending online classes (B), degree to which distance activities affected learning (C), concentration impaired by the COVID-19 pandemic (D), effectiveness of teaching method (E), overall satisfaction with the subject (F), and feeling prepared for the professional future (G) in different academic semesters (RE-AIM Effectiveness Domain).

RE-AIM Domain 3 (Adoption)

A comparison of the frequency of aspects that may have interfered with learning in relation to the different semesters of data collection is shown in Table 3. In the total sample, 62.74% of students totally agreed that they felt more anxious during the period of online activities. The different periods of the pandemic (2020.2, 2021.1, and 2021.2) were used to assess variations in emotional state and to relate possible effects on the students' learning process. The only factor that differed between the groups was impaired concentration in studying (p = 0.031). For this factor, the highest frequency of the sum of the "totally agree" and "agree" categories (82.6%) was in semester 2021.1, while the "totally disagree" response had a higher frequency in semesters 2020.2 (39.1%) and 2021.2 (24.2%). In addition, video lectures that are recorded and available for students to watch as long as they want, with the opportunity to ask questions of the instructor, was the preferred format (99.0%). The majority of students agreed/totally agreed that they felt more mental fatigue during the pandemic.

Figure 3 shows the frequency of difficulties reported by students with online courses. In the total sample, regardless of semester, the most common difficulty was related to connection problems (66.7%), followed by loss of focus (44.1%). In the comparative analysis between semesters, there were statistically significant differences in the frequency of connection problems (p = 0.001). In semester 2021.1, 84.8% of the students reported these difficulties with the Internet connection, while in 2020.2 and 2021.2 this percentage was 43.5% and 57.6%, respectively. In addition, lack of interaction also showed differences between semesters (p = 0.041), no students reported this difficulty in class 2020.2, but this percentage increased to 19.6% and 21.2% in the following two semesters.

It also analyzed whether the pattern of difficulties experienced with online teaching was associated with previous experience with this teaching method (Figure 4). A statistically significant association was found between these two factors (p = 0.003). In the group of students who reported having a lot of difficulty with online teaching, 40% had never had experience and 60% had rarely dealt with this type of method. On the other hand, all the students who reported having no difficulty with the method had had some previous experience with it and within this group it was observed that 13.4% of the students reported frequent experience and 26.7% mentioned that they had sometimes tried distance learning.

Table 3. Distribution of students' perception of the distance learning method (RE-AIM Adoption Domain).

Variables	Academic semester			P
	2020.2	2021.1	2021.2	
	%	%	%	
The activities were clear and fair				*0.881*
Totally agree	78.3	73.9	84.8	
Agree	17.4	19.6	15.2	
Neither agree nor disagree	4.3	4.3	-	
Disagree	-	2.2	-	
Totally disagree	-	-	-	
Regarding the current moment, I felt more anxious during this period				*0.854*
Totally agree	69.6	65.2	54.5	
Agree	21.7	26.1	30.3	
Neither agree nor disagree	8.7	8.7	9.2	
Disagree	-	-	3.0	
Totally disagree	-	-	3.0	
Being in a pandemic impairs my attention to my studies				*0.031**
Totally agree	39.1	32.6	30.3	
Agree	17.4	50.0	36.4	
Neither agree nor disagree	4.3	8.7	6.1	
Disagree	-	2.2	3.0	
Totally disagree	39.1	6.5	24.2	
I felt more mentally tired during this period				*0.386*
Totally agree	30.4	43.5	57.6	
Agree	30.4	34.8	24.2	
Neither agree nor disagree	17.4	8.7	3.0	
Disagree	17.4	10.9	15.2	
Totally disagree	4.3	2.2	-	
I started doing more academic activities during the pandemic				*0.597*
Totally agree	47.8	26.1	39.4	
Agree	8.7	21.7	18.2	
Neither agree nor disagree	26.1	28.3	15.2	
Disagree	17.4	19.6	24.2	
Totally disagree	-	4.3	3.0	

*Indicates statistically significant differences (p <0.05).

A

Difficulties reported

Internet connection problems — 66.7%
Loss of focus — 44.1%
Difficulty adapting — 26.5%
Lack of interaction — 15.7%
No difficulty — 10.8%
Difficulty answering questions — 5.9%

Percentage (%)

B

Internet connection problems
P = 0.001

■ Yes
▫ No

Percentage (%) / Academic semester (2020.2, 2021.1, 2021.2)

C

Loss of focus
P = 0.115

■ Yes
▫ No

D

Difficulty adapting
P = 0.839

■ Yes
▫ No

E

Lack of interaction
P = 0.041

■ Yes
▫ No

F

No difficulties
P = 0.553

■ Yes
▫ No

G

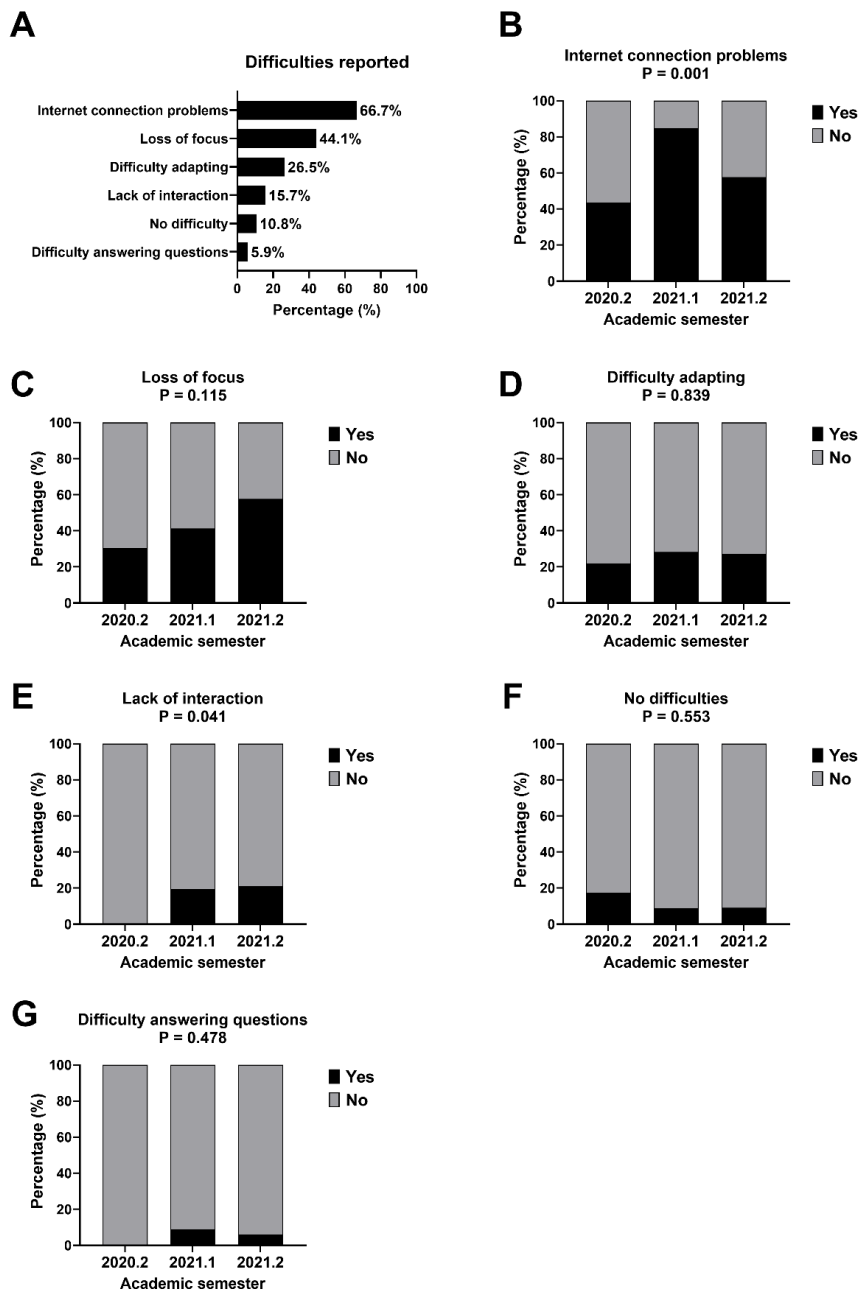**Difficulty answering questions**
P = 0.478

■ Yes
▫ No

Figure 3. Distribution of the total frequency of difficulties in remote teaching (A) and comparative analysis between academic semesters for the variables: problems with the connection (B), loss of focus (C), difficulties in adapting to the platforms (D), lack of interaction (E), no difficulties (F) and difficulties in answering questions (G) (RE-AIM Adoption Domain).
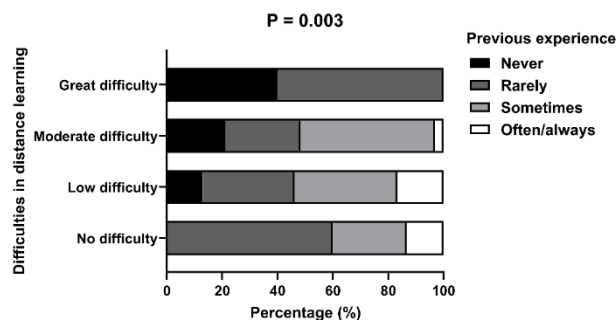
P = 0.003

Difficulties in distance learning: Great difficulty, Moderate difficulty, Low difficulty, No difficulty

Previous experience
■ Never
▨ Rarely
▫ Sometimes
□ Often/always

Percentage (%)

Figure 4. Association between frequency of difficulties in remote teaching and previous experience with online classes (RE-AIM Adoption Domain).

RE-AIM Domain 4 (Implementation)

The students' evaluation was also analyzed in relation to the aspects of the course offered (Table 4). The results showed that there were no statistically significant differences in the distribution of evaluation patterns between the groups by academic term. In the total sample, 80.4% of students took breaks to take notes during online courses. In terms of the time of day they attended class, 46.07% of students attended online classes between 8 am and 5 pm, 33.3% between 7 pm and 11 pm, 12.74% between 5 pm and 7 pm, 4.9% at another time, and 2.94% between 11 pm and 8 am. The majority of students totally agreed that the subject stimulated learning (66.7%).

In addition, over the three semesters collected, the majority of students considered the synchronous meeting to answer questions, the ability to view lessons more than once, and the organization of the course to be the best aspects of the course.

Table 4. Distribution of the variables that evaluate the course according to different academic semesters (RE-AIM Implementation Domain).

Variables	Academic semester			p
	2020.2	2021.1	2021.2	
	%	%	%	
The orthodontics course was well organized				0.617
Totally agree	82.6	71.7	84.8	
Agree	17.4	26.1	15.2	
Neither agree nor disagree	-	2.2	-	
Disagree	-	-	-	
Totally disagree	-	-	-	
The course encouraged me to learn				0.057
Totally agree	78.3	54.3	75.8	
Agree	13.0	32.6	24.2	
Neither agree nor disagree	8.7	13.0	0.0	
Disagree	-	-	-	
Totally disagree	-	-	-	
What time of day did you usually watch the videos?				0.126
Between 8 am and 5 pm	47.8	56.5	30.3	
Between 5 pm and 7 pm	8.7	13.0	15.2	
Between 7 pm and 11 pm	39.1	19.6	48.5	
Between 11pm and 7 am	4.3	2.2	3.0	
Other time	-	8.7	3.0	
Indicate the alternative that best describes your viewing habits of the pre-recorded lesson material on the MOODLE Platform				0.669
When I was watching, I was also doing other activities	4.3	2.2	-	
When I was watching, I was focused and writing down the content with the video playing	8.7	4.3	3.0	
When I was watching, I was focused, watching only the videos	8.7	17.4	9.1	
When I was watching, I paused the recordings to take notes	78.3	76.1	87.9	
Regarding the number of times you accessed the videos, please select the option you used the most during the course				0.657
I viewed the lessons only once	8.7	10.9	6.1	
I reviewed the lessons occasionally as I felt the need	69.6	47.8	51.5	
I have reviewed almost all of the lessons	8.7	15.2	21.2	
I have reviewed all of the lessons	13.0	26.1	21.2	

RE-AIM Domain 5 (Maintenance)

The maintenance domain was evaluated by asking open-ended questions to the students. When asked about possible improvements, the students almost unanimously agreed that the methodology had been prepared in the best possible way. The only disagreement was about the length of the recorded lessons, where the students pointed out that it would be interesting if they all lasted no more than 30 minutes.

DISCUSSION

The use of educational technologies to mediate teaching has been widely discussed and necessary during the COVID-19 pandemic due to the suspension of several face-to-face activities. Faced with this situation, Berry et al. (2021)[8] proposed the reformulation of a course using blended learning (hybrid teaching) applied through a flipped learning methodology as an alternative for teaching in dentistry, specifically in the field of orthodontics. The hybrid teaching model is not new in dental education and has been described as effective compared to the traditional model for teaching theoretical content in preclinical subjects in a non-pandemic environment[8,12-15].

Our results show that the hybrid learning method used was perceived as satisfactory by the students and effective according to the RE-AIM framework, even during the pandemic. Al-Fodeh et al. (2021)[7] also found a positive result regarding hybrid teaching in dentistry during the COVID-19 pandemic. According to the authors, hybrid learning should become the preferred teaching method in times of social isolation.

A feature of the model developed and implemented that may have contributed to the positive results was the use of different active methods within a hybrid program. It is believed that the use of an online teaching-learning process requires the development of an interactive pedagogical project, centered on the student and aimed at engagement. In this sense, the use of active methodologies can be an ally. Although the course did not use active methodologies before the pandemic, the teachers involved in planning the course were working on lines of research in this area.

Regarding connectivity and electronic devices, it was noted that although the study was conducted in a public university, there was no lack of equipment and access (technology and Internet) on the part of the students. When implementing a hybrid teaching model, it is essential to ensure fairness in the requirements needed for a fair and comprehensive learning process. This was also observed in a similar study carried out at the Araçatuba School of Dentistry, in the state of São Paulo. According to the authors, the difficulties reported were similar to those identified in this study: technical problems and connectivity[16]. However, the issue of digital marginalization needs to be discussed when it comes to the implementation of technology in dental education[17].

Still within the Reach domain, it was observed that as the COVID-19 pandemic progressed, the ideal class time preferred by students increased. In semesters 2021.1 and 2021.2, the majority of students chose 30- or 45-minute classes, and some preferences for 1-hour classes were obtained (Table 1 and Figure 1). This change may be due to the fact that during these periods the vaccine was already being administered and theoretical classes were beginning to resume (more movement in the streets and university spaces), students felt more comfortable dedicating more time to theoretical classes, unlike what was found in the study by Silva et al. (2022)[18]. In assessing how dental students from eight universities accessed, used, and learned from online videos during the pandemic, the authors found that the preferred duration of video lessons was fifteen minutes.

In terms of the profile of the students in this study and their difficulties with the online teaching method, the results of domains 2 and 3 indicate that even without prior experience with online teaching, the students did not report any difficulties with the teaching model. A possible explanation for this, based on the age group of the students, is that they are digital natives. This analysis was also reported by He et al. (2020)[19]. According to the author, one of the reasons why hybrid teaching was effective and feasible for health sciences students was the fact that this sample consisted of students who had grown up with electronic devices and were familiar with using the Internet. As briefly mentioned in the previous paragraph, the main difficulties reported by the students in the study were technical problems and connectivity. As also pointed out by Moimaz et al. (2022)[16] in Araçatuba, the scoping review published by Kerkstra et al. (2022)[20] reinforces these findings. In this review, the authors identified the benefits and technical barriers faced by students and

found that WiFi interruption and problems with virtual platforms were the most recurring issues. Difficulty achieving student engagement, lack of interaction when students didn't turn on cameras, and time management of synchronous meetings were also reported[16-20].

Analysis of the items in Domain 2 of the RE-AIM shows a high level of satisfaction with the quality and effectiveness of learning orthodontic content. These data are consistent with other authors who have implemented technology-mediated instruction at their educational institution. Cho and Ganesh (2021)[21] used a hybrid format to teach dentistry in the field of radiology at the University of Maryland in the United States and evaluated the perception and benefits of virtual learning during the COVID-19 pandemic, concluding that the materials used virtually increased the level of knowledge and confidence of the students, suggesting that the integration of technology-mediated teaching in the curriculum of dentistry would be a good choice of methodology in the academic training of students.

In this sense, in Domain 2, in addition to the perception questions, the students' grade point averages were also assessed. Among the classes evaluated in this study, there was no significant difference in the average scores of the students' grades, which indicates that even in different periods of the COVID-19 pandemic, with the difficulties inherent to this period and the difficulties presented by the methodology, the level of achievement of the students was similar and above 80%. In the field of education, there is much discussion about assessment formats being a combination of summative and formative actions, so having positive results in both areas is a positive point of the methodology developed[22].

The findings in Domain 2 corroborate the findings in Domain 3 (Adoption), which assessed how students engaged with and accepted the course. There was no statistically significant difference between students across the three semesters in totally agreeing or agreeing that the activities proposed by the course were clear and fair. When thinking about the effectiveness and acceptance of a course or discipline, it is important to compare results with other places. Even in a different cultural reality, but experiencing the same pandemic, a study conducted at Nanjing University in China concluded that the online curriculum developed to teach the theoretical content of undergraduate orthodontics enriched critical thinking and problem solving, and students obtained better summative grades[23]. In the same vein, Mucke et al (2023)[24] asked whether "there is a lasting effect of the COVID-19 pandemic". According to the authors, the hybrid teaching method seemed to compensate for the negative effects experienced during the pandemic and allowed students to achieve the same level of learning as before the pandemic.

The findings of Domains 4 and 5 corroborate everything described above in terms of the methodology developed and applied. In terms of implementation, it is worth highlighting issues related to infrastructure as described by Sigh et al. (2021)[25]. The authors pointed out important factors to ensure a meaningful learning experience in hybrid teaching, such as adequate infrastructure, teacher training, innovative technology, pedagogical methods to build relationships and improve social, cognitive, and instructional presence, and rigorous quality assurance methods. In this study, the presence of faculty familiar with educational technology and experienced in hybrid teaching was essential, as was the expertise and technology provided by the university's Teleodontology Center. The lack of teacher training and the need for it have been described by Nascimento et al. (2021)[26]. According to the authors, some reasons for this lack of training are lack of interest, difficulty in accessing training and lack of financial incentives. In addition, the authors emphasize the importance of the role of this teacher in the process of preparing the course design and learning objects, which requires an expensive workload for these activities, in addition to their presence as a mediator throughout the student's learning process. Regarding the maintenance of this teaching format, the results of this study showed that the students almost unanimously agreed that the methodology was designed in the best possible way.

The evaluation of an educational methodology has some limitations inherent to the nature of the study and extrapolation of results must be done with caution. With regard to the specificity of the preclinical course, it was possible to provide the theoretical classes in advance and only then start the laboratory activities, taking into account the atypical schedule of the pandemic. Some sample size limitations were inherent to the convenience sample adopted in the study, which included only students duly enrolled in the course, collected from a single educational institution. Thus, studies with larger sample groups and different sociocultural profiles should be conducted to investigate the influence of factors on student learning in the face of the technology-mediated teaching model. It is worth noting that this study did not make a

comparison with traditional teaching and that the results should not be interpreted to promote distance education in dentistry. It is believed that regardless of the pandemic, this hybrid teaching model can be maintained based on the advantages of each learning method, broadening student acceptance and providing greater flexibility.

CONCLUSION

Based on what has been evaluated, it can be concluded that, according to the results of the RE-AIM framework, the method applied and developed was effective and positively perceived by the students at the time of the COVID-19 pandemic, regardless of the phase of the pandemic they were in. In this sense, it can be understood that this method can be used in times of social isolation, as well as a future model for the implementation of disciplines that wish to integrate educational technologies into the dental curriculum. It is suggested that more long-term studies be carried out to find the best alternatives for the use of educational technology in the training of dental surgeons, and that the studies use similar evaluation instruments to compare the findings.

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