

# Dental students' and faculty perception of online exams with e-invigilation in Cyprus

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## Abstract

**Introduction:** During the recent pandemic, e-learning and e-assessment methods have been implemented worldwide, providing opportunities for further implementation in the dental curriculum. This study aims to research the dental students' and dental faculty's perceptions of online exams with e-invigilation.

**Materials and Methods:** Online questionnaires were developed and delivered, after three semesters of online exams, to all students and faculty. Descriptive statistics were performed, and answers were grouped into Principal Components (PC) using Principal Component Analysis (PCA). Statistical significance was set at  $p < .05$ .

**Results:** Two-hundred and sixty dental students (83.7%) and 24 dental faculty members (63.1%) answered the online questionnaires. PCA of students' responses revealed 4 PC, 'University support to students', 'Comparison between online and face-to-face exams', 'Preparation for the online exams' and 'Attitudes towards the technology used for the online exams'. PCA of faculty responses revealed 5 PC: 'Comparison between online and face-to-face exams', 'University support to faculty', 'Faculty attitudes towards the exam procedures', 'Human factors associated with the exam procedures' and 'Exam invigilation'. The overall satisfaction was high for both staff and students (higher for students and female staff). Students with previous experience in online exams scored more positively than first-year students. University support, process-related stress and e-invigilation were highlighted.

**Conclusions:** The overall satisfaction with the e-exams was high, despite the technical problems, time-consuming processes and related stress. University support (training, IT support and resources) and mock exams emerged as important elements of online exams, as was the e-invigilation, which students perceived as efficient and non-intrusive.

## KEYWORDS

COVID-19 pandemic, dental education, e-assessment, invigilation, online exams, student evaluation

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## 1 | INTRODUCTION

Undergraduate Dental education is traditionally delivered face-to-face, as significant components of the learning process are practical (hands-on), pre-clinical and clinical training. However, during the COVID-19 pandemic, the subsequent lockdowns and social distancing measures, most Dental Schools shifted to online learning, at least for the theoretical courses and labs suitable for online teaching, while other laboratory and clinical training courses were suspended until the appropriate health measures were in place and the situation was improved or resolved.<sup>1,2</sup> Similarly, clinical competences' evaluations were postponed by the majority of Schools in Europe and worldwide, whereas formative and summative assessments were either postponed or organized online.<sup>3</sup> This transition to online learning and assessment was an emergency, not underpinned by sufficient experience or substantial research, nor supported by relevant training for the educators and the students; however (or maybe because of these deficiencies), it presented unique opportunities to implement cutting-edge educational reforms, which would not have been possible to happen under normal circumstances, to such a large extent.<sup>4</sup> Thus, many of the 'emergency' online educational procedures have remained in the post-COVID era, having been tested and proven to offer significant advantages. For example, online exams offer numerous possibilities, such as the inclusion of high-quality photographs and radiographs for diagnosis and treatment planning, automatic correction of MCQs, elimination of human error, automatic grading and announcing of results, immediate feedback and even contribution to a 'green planet' (no printed paper) and GDPR compliance (no hard copies in closets or easily accessible areas).

Different dental students' perceptions of online teaching have been reported as well as the impact that online education had on their academic and social lives.<sup>5-7</sup> Despite its limitations and the associated pedagogical and technological challenges, e-learning through different educational platforms can offer an alternative and viable means of delivering a part of undergraduate Dental education.<sup>8</sup>

All methods of teaching require both formative and summative assessments to complement each other.<sup>9-12</sup> Formative assessment during online teaching can be achieved through different types of assignments, class discussions, projects, presentations, group activities and other possibilities offered by the Learning Management Systems (LMS) and supported by contemporary educational methods. Summative assessment takes place at the end of a semester of a course, usually as final exam.<sup>13</sup> Online assessment poses several challenges such as remote invigilation, technical difficulties such as interruption of the student or faculty internet connection, computer crashes, difficulty in finding a quiet place to take the exam, need to master the technology so that the focus is on the exam and not on the hardware or software used, and many other obstacles.<sup>14</sup> A number of recent studies exist that show the effectiveness and student perceptions of online exams (with or without e-invigilation).<sup>14-20</sup> Online assessment has been implemented and evaluated, among others, for pre-clinical fixed prosthodontics,<sup>21,22</sup> oral radiology,<sup>23</sup> dental

anatomy,<sup>24</sup> periodontology<sup>25</sup> and for online OSCEs to test students' clinical competencies.<sup>17-19,25</sup> Various conclusions and recommendations were drawn in relation to the pedagogical, technological and emotional aspects of this methodology. Successful implementations were reported,<sup>4,24,26,27</sup> but also disadvantages and challenging aspects were identified, including technical problems related to internet connectivity/e-exam platforms,<sup>4,28,29</sup> stress and anxiety,<sup>4,15,16,18</sup> mental health and students well-being,<sup>3,20,28</sup> security and cheating issues<sup>4,30-32</sup> and the institutions' support.<sup>14,19,28</sup>

The Department of Dentistry, School of Medicine, European University Cyprus is a new Dental School that accepted the first cohort of dental students in September 2017 and had its first graduates in the summer of 2022. Since September 2022 and after successful accreditation from the Cyprus Agency of Quality Assurance and Accreditation in Higher Education (CYQAA), it became independent from the School of Medicine and is now School of Dentistry. It has a modern infrastructure and an emphasis on new technologies, simulation methods, software-supported teaching and other media that generally promote digitally enhanced learning.

In March 2020, as happened globally, a general lockdown took place in Cyprus. Provided that a full IT Department was already in operation (MIS, Management Information Systems), an LMS set-up for online or blended learning was in place, and that the University has a large Distance Education Unit with technical and pedagogical methods of distance learning already established, a swift change could take place in the Department of Dentistry. Within 4 days, it started to offer all theoretical courses online. After a short break, and with the permission of the relevant authorities, the operation of the necessary face-to-face laboratories (pre-clinical and simulation labs) and the clinics resumed normally, following the procedures for social distancing, personal protective equipment use, testing, disinfection of the premises and all other protocols in effect to prevent the spread of COVID-19. During the following four semesters, until January 2022, exams were performed online. The end-of-semester exams are a summative assessment that accounts for 60% of the total course grade. They took place in the LMS Moodle and LMS Blackboard (in fall semester 2021) with the use of Respondus Lockdown browser for e-invigilation.

The aim of this study was to research the dental undergraduate students' and dental faculty perceptions of online exams with e-invigilation. Secondary aims were to identify and correlate the key factors influencing these perceptions.

## 2 | MATERIALS AND METHODS

Perceptions of students and faculty on the online exams were identified through online questionnaires. Specifically, an online questionnaire was developed, approved by the University Ethics Committee and the Vice-Rector for Research and External Affairs, and delivered after the online exams of fall semester 2021 to all students that took the exams, along with a consent note to participate in the study. The total number of students invited to participate in the survey was 310.

Another questionnaire was delivered to all course coordinators that set up the online exams. The total number of course coordinators invited was 38. The questionnaires were adapted from Khalaf et al.<sup>14</sup> The students' questionnaire comprised 18 questions and an overall assessment question, answered on a 5-point Likert scale. The faculty questionnaire consisted of 16 questions and an overall assessment question. Sampling in the present study was conducted by using a convenience sample approach while aiming for a response rate of or above 60%. The platform used for the survey was Google Forms.

The LMS used for the set-up of the exams was Moodle (Moodle Pty Ltd.) for years 2–5, and Blackboard Learn© (Blackboard Inc.) for year 1, due to the transition of the University LMS from Moodle to Blackboard Learn. The software for e-invigilation was Respondus Monitor and LockDown Browser (Respondus, Inc.), a system that locks student interface in the exam window with no other permissions unless the instructor activates specific webpages (it prohibits printing, accessing other web pages, chatting, social media, etc). In addition, Respondus Monitor provides exam recordings, available after the exam has ended, but it does not provide real-time (synchronous) viewing. Students connect to the online exam through the Respondus software, after appropriate consent is obtained. The program guides them through the process, constantly monitors them during the exam via the computer camera and provides alerts to the instructors so they can check the video recordings and ask for explanations in case there is suspicion (red flag) of cheating. Students took the exams outside the University premises (usually at home) with books and teaching materials closed. The exam webpage was made accessible to them automatically at the designated time and date. Before starting the exam, they were asked by the software to show and record proper identification to verify their identity. After this initial check-in process was completed, the exam timer started. Students were required to maintain a visual and audio connection throughout the exam session. In case of internet disconnection or other technical problems, students would immediately notify their instructor by e-mail, telephone or a Blackboard collaborate room set for the exam, who would provide technical guidance using a troubleshooting guide, developed and distributed ahead of the exams by the MIS department. In case the problem was not resolved, the instructor would ask for the assistance of the IT department. Once the problem was resolved, the student was re-admitted to the exam webpage and would have the same remaining time, as the countdown timer would freeze during disconnection.

The exam rules were similar for all courses for the purpose of uniformity and the procedure's simplification. For the first 3 years of study (non-clinical), all course exams comprised 60 Multiple Choice Questions (MCQ), with one or multiple possible correct answers. Negative markings existed for questions with multiple correct answers, but the total question mark could not be less than zero. The order of questions and the possible answers were randomly and automatically shuffled by the system so that they were presented differently to each student to prevent cheating. The questions had to be answered one by one in the given order for each student, with an option to return to the previous question, preview the next

questions or have a quick overview of all the exam questions. For the clinical years (4th and 5th), there were 20 MCQs and 10 essay-type questions for all courses, which were clinically related, requiring critical thinking and knowledge combination.

A detailed exam manual and troubleshooting guide were developed for the faculty, as well as another manual for the students. The manual was developed for all the University's Schools and Departments, but it was customised for the Department of Dentistry by one of the online exam coordinators. Webinars were given to faculty and students and mock exams, both synchronous and asynchronous, were also organized. Thus, all students and instructors had, ahead of the actual exam, exposure and training to the exam procedures. Further to that, possible technical issues could be resolved during the mock sessions, as the students were asked to take these mock exams under the exact same conditions they would take the actual exams.

## 2.1 | Statistical analysis

The mean values and standard deviations for students' and faculty's answers were calculated. Moreover, their answers were grouped exploratorily into sets of questions that express or compose the same conceptual structure (Principal Components - PC) using Principal Component Analysis (PCA) and implementing the VARIMAX orthogonal rotation method with Kaiser Normalization. To determine the number of statistically significant components, the latent root criterion (eigenvalue>1) was employed.<sup>33</sup> Furthermore, Bartlett's test of sphericity and Kaiser-Meyer-Olkin measure of sampling adequacy were both used to test the factorability of the correlation matrix. In addition, for each component, Cronbach's alpha and the average Discrimination Index (DI) were used to test reliability and internal consistency.<sup>34</sup> The reliability and internal consistency scores allowed to calculate a total PC score for every responder.<sup>35</sup>

The correlation of students' PC scores with their year of study and the overall assessment was tested by Kendall's tau. Moreover, a series of non-parametric Mann-Whitney U tests between students' PC scores/overall assessment and previous experience with online exams (first-year students vs. years 2–5) was performed.

For faculty, the correlation of PC scores with gender, age, number of courses taught, and the overall assessment was tested by Kendall's tau. In addition, a series of non-parametric Mann-Whitney U tests between PC scores/overall assessment and gender was performed. The observed significance levels (*p* values) of all non-parametric tests (Mann-Whitney U and Kendall's tau) were estimated by the Monte-Carlo simulation method.<sup>36</sup>

All the analyses were performed using SPSS (version 25.0; SPSS Inc, Chicago, IL), and statistical significance was set at  $p < .05$ .

## 3 | RESULTS

Two-hundred and sixty dental students (out of 310) answered the online questionnaire (response rate=83.7%) and 24 (out of 38)

faculty members (response rate=63.1%) (17 females, 7 males; age  $51 \pm 10$ ; range: 34–69). Tables 1 and 2 present the descriptive statistics (means, standard deviations) for the students and faculty questionnaires respectively. In general, e-invigilated online exams were perceived positively by students and faculty. Mean scores in students' questionnaires were rather high, ranging from 4 to 4.43 in the 5-point Likert scale, except for the 'negative' questions, where they ranged from 2.41 to 2.55; all answers indicate positive perceptions. In the faculty's questionnaire, mean scores ranged from 3 to 4.33 and from 2.33 to 3.29 for the 'negative' questions, indicating rather positive perceptions, although—apparently—less positive than these of the students.

PCA for student answers revealed 4 Principal Components, explaining 60.6% of the total information (University support to students, Comparison between online and face-to-face exams, Preparation for the online exams and Attitudes towards the technology used for the online exams), while for faculty answers, it revealed 5 Principal Components explaining 75.5% of the total information (Comparison between online and face-to-face exams, University support to faculty, Faculty attitudes towards the exam procedures,

Human factors associated with the exam procedures and Exam invigilation) (Table 3 and Appendices 1, 2).

The correlations of student answer PC scores with the year of study and the overall assessment are presented in Table 4. There were no statistically significant correlations between the year of study and the 4 PC, but there were strong, significant correlations between the 4 PC scores and the general assessment question 'Overall, I was satisfied with this online exam'. Students with previous experience with online exams (years 2–5) scored more positively than 1st-year students in all PC scores except in the 'Attitudes towards the technology used for the online exams' (Table 5).

The correlations of faculty answer PC scores with gender, age, number of courses taught and the overall assessment are presented in Table 6. There were strong significant correlations between all principal components and the general question 'Overall, I was satisfied with this online exam' and between gender and the 3rd ('Faculty attitudes towards the exam procedures') and 5th ('Exam invigilation') principal components. A series of Mann-Whitney U tests revealed that females scored more positively than males regarding faculty attitude towards the exam procedures (males mean: 3.55, females

TABLE 1 Descriptive statistics: Student survey questionnaire. Likert scale: 1 (strongly disagree) – 5 (strongly agree).

Questions	Mean	SD	Principal components
Q1 Exam instructions were clearly addressed to me	4.39	0.819	1
Q2 I have adequate previous experience in online learning systems (e.g. Moodle, Blackboard, MS Teams, Zoom, etc.)	4.22	1.078	3
Q3 The training manuals, webinars and mock exams for the online exam were adequate to familiarize me with the exam	4.43	0.810	1
Q4 The training and the mock exam received made me feel less anxious about the online exam	4.06	1.126	3
Q5 I was satisfied with the accessibility and availability of the online exam coordinators (in the Department of Dentistry) to solve any issues before and during the exam	4.23	1.006	1
Q6 I was satisfied with the accessibility and availability of the IT Department (MIS) of the University to solve any issues before and during the exam	4.07	1.054	1
Q7 I was satisfied with using Moodle and Respondus for the online examination	4.25	1.018	1
Q8 I felt uncomfortable with the Respondus lockdown browser for e-invigilation	2.41	1.410	4
Q9 I feel Respondus lockdown browser was an acceptable method to invigilate the online exams	4.13	1.025	1
Q10 My online exam grade reflects my performance	4.21	0.953	2
Q11 Online exams are more flexible and accessible than paper-based exams	4.02	1.230	2
Q12 Online exam marking is more reliable since there is no human error	4	1.172	2
Q13 Technical problems such as internet connection issues or computer crashes affected my performance in the online exam	2.42	1.314	4
Q14 The technology used in online assessments is reliable	4.13	0.889	4
Q15 Online assessments favour some students more than others	2.55	1.428	4
Q16 The online exam duration was sufficient	4.33	0.868	3
Q17 I enjoyed the features of the software used in online exams	4.04	1.024	2
Q18 I feel that e-invigilation with Respondus lockdown browser was not giving a chance to cheat	4.02	1.266	2
Q19 Overall, I was satisfied with this online exam	4.33	0.958	

TABLE 2 Descriptive statistics: Faculty survey questionnaire. Likert scale: 1 (strongly disagree) – 5 (strongly agree).

Questions	Mean	SD	Principal components
Q1 Before the online exams, I had adequate previous experience in online learning systems (e.g. Moodle, Blackboard, MS Teams, Zoom, etc.)	3.33	1.167	4
Q2 The technology used for setting and administering the online exam was reliable	4.08	0.974	1
Q3 The training manuals, webinars and the mock exams for the online exam were adequate to familiarise myself with the exam set-up	4.04	0.751	2
Q4 The method used for invigilating the exam (Respondus lockdown browser) was reliable and prevented cheating	3.00	1.103	5
Q5 In order to detect students that were cheating, I checked carefully and watched all high-alert video recordings provided by Respondus lockdown browser	3.88	0.850	3
Q6 I checked all high alerts, most medium alerts and a few low-alert recordings provided by Respondus lockdown browser	3.71	0.999	3
Q7 I was satisfied with the accessibility and availability of the online exam coordinators (in the Department of Dentistry) to solve any issues before and during the exam	4.33	0.761	3
Q8 I was satisfied with the accessibility and availability of the IT Department (MIS) of the University to solve any issues before and during the exam	3.54	1.250	2
Q9 I faced significant technical difficulties setting up the online exam	2.33	1.239	2
Q10 It was more difficult for me to conduct the online exam than in the traditional setting	3.29	1.268	2
Q11 The online exam made the students and the Faculty more anxious than in the traditional setting	3.29	1.197	2
Q12 The possibilities offered by the online exam platform (e.g. different % marking for each answer, the ability to upload pictures and X-rays, the combination of a single correct answer with multiple correct answers) were significant tools in the student assessment	3.92	0.654	1
Q13 Overall, I prefer online exam grading in comparison to paper-based grading	2.96	1.367	3
Q14 Online exams are more flexible and accessible than paper-based exams	3.17	1.239	1
Q15 Online exam marking is more reliable since there is no human error	3.33	1.129	1
Q16 I feel that an online exam is in total more time-consuming than traditional face-to-face exams (taking into account setting up, uploading questions, reporting, and student accessibility)	3.67	1.167	4
Q17 Overall, I was satisfied with this online exam	3.38	0.970	2

mean: 4.25,  $p=.003$ ), the assessment of the invigilation method (males mean: 2.71, females mean: 3.71,  $p=.031$ ) and the overall assessment (males mean: 3.12, females mean: 4.00,  $p=.04$ ).

Additional correlations using Kendal's tau were explored between students' answers to each question and previous experience with online exams (first-year students vs. years 2-5) and the overall assessment, as well as between faculty answers to each question and gender, age, number of courses taught and the overall assessment (Tables 7 and 8). For students, the 'overall satisfaction' was significantly correlated with all questions, and the 'study year' was significantly correlated with the 'previous experience in online learning systems' and with the 'online exam duration'. For faculty members, gender was significantly correlated with the 'satisfaction with the availability of the exam coordinators' and with the perception of 'time-consuming online exams'; age was significantly correlated with the 'accessibility and availability of the IT Department of the University to solve any issues'; the 'overall satisfaction' was significantly correlated with the 'reliable technology', the 'technical difficulties', the 'difficulties in conducting the online exam', the 'creation of anxiety to students and faculty', the

'usefulness of the possibilities offered by the platform', the 'preference for online exams vs paper-based ones', the 'flexibility of online exams', the 'reliability of marking' and the 'time-consuming element of online exams'.

## 4 | DISCUSSION

Summative exam-based assessments aim to inform educators about students' progress, monitor the process of teaching and learning and determine whether educational goals and students' needs are met.<sup>16</sup> To that end, student assessment should be objective, valid and reliable, and aligned to the learning outcomes of the course. Up until the COVID-19 pandemic crisis, online assessment (and to a lesser degree, online learning) was marginal and sparse in Dental education. However, the pandemic and the subsequent need to safeguard the health of students and staff forced universities to use alternative approaches and implement online learning, along with the online summative assessment as the only evaluation method for students and courses.<sup>16,19,25</sup> Although there were reports of less

TABLE 3 Principal components and component scores for students' and faculty answers.

Principal component	Variance (%)	Cronbach's $\alpha$	DI	Mean	SD
Students					
First: University support to students	42.6	0.869	0.671	4.25	0.747
Second: comparison between online and face-to-face exams	6.8	0.804	0.592	4.05	0.850
Third: preparation for the online exams	5.9	0.535	0.352	4.20	0.741
Fourth: attitudes towards the technology used for the online exams	5.3	0.340	0.204	2.87	0.740
Faculty					
First: comparison between online and face-to-face exams	32.9	0.379	0.324	3.37	0.710
Second: university support to faculty	15.7	0.808	0.603	3.53	0.502
Third: faculty attitudes towards the exam procedures	10.8	0.753	0.553	3.76	0.587
Fourth: human factors associated with the exam procedures	8.8	0.621	0.451	3.33	0.601
Fifth: exam invigilation <sup>a</sup>	7.3			3	1.103

<sup>a</sup>The fifth principal component included only one question, therefore Cronbach's alpha and Discrimination Index could not be calculated.

TABLE 4 Correlations of students' PC scores (Kendal's tau).

Principal component	Year of study	Overall assessment
First	$\tau=0.084, p=.081$	$\tau=0.586, p<.001$
Second	$\tau=0.008, p=.865$	$\tau=0.683, p<.001$
Third	$\tau=0.003, p=.944$	$\tau=0.427, p<.001$
Fourth	$\tau=0.029, p=.541$	$\tau=-0.457, p<.001$

Statistically significant values are in bold.

successful implementations of online exams<sup>37,38</sup> and valid scepticism on its suitability for assessing clinical competencies (e-OSCEs) was expressed,<sup>3,17-19</sup> the majority of reports appreciate the advantages of e-assessment, while not underestimating its challenges and disadvantages.<sup>4,20,21,25,28</sup>

A variety of online platforms and tools were used in dental education during the recent pandemic, such as laptops, smartphones, tablets, desktops, Blackboard, Moodle, Zoom, Google rooms, Skype, Microsoft Teams, WebEx, Respondus Lockdown Browser, eProctor and PowerPoint.<sup>4,39</sup> A plethora of online assessment methods were also utilized, including synchronous and asynchronous methods, written assignments, portfolios, essays, oral exams, presentation of clinical cases, group discussions, multiple choice questions (MCQs), e-OSCEs, extended matching questions (EMQs), short answer questions (SAQs), true/false and 'fill in the blank' items, etc.<sup>17,19,28,39</sup> In the present research, MCQs were used within the Moodle and Blackboard LMSs, in combination with the Respondus Lockdown Browser e-invigilation software. Some interesting issues and aspects emerged from this research, in relation to student and faculty perceptions of e-exams.

Overall satisfaction with online exams was more positive for the students (mean 4.33) than for the faculty (mean 3.38). It seems that

TABLE 5 Mann-Whitney U tests between PC scores and previous experience with online exams (first-year students vs. years 2-5).

Principal component	1	2-5	<i>p</i>
	Mean scores	Mean scores	
1	4.08	4.29	<b>.002</b>
2	3.97	4.08	<b>.036</b>
3	3.99	4.26	<b>.002</b>
4	2.95	2.86	.233
Overall assessment	4.39	4.32	.611

Statistically significant values are in bold.

students were considerably more satisfied with the online exams than their educators. This can be attributed to several reasons: faculty members were less experienced in online learning systems (mean answers' score 3.33, Question 1) than students (mean answers' score 4.22 in the relevant question—Question 2). Faculty members may feel overwhelmed with the numerous tools and applications they have to choose from and unable to address even minor technological problems.<sup>4,28</sup> Moreover, as reported elsewhere, the set-up of online exams requires significantly increased time, to both familiarize with the software and upload the exam content to the platform,<sup>14,18</sup> as well as sufficient training ahead through webinars and guidebooks. Finally, the exam process itself is a stressful situation for educators. On the other hand, students are digital experts; they adapt easily to new online environments, they like to learn using innovative digital tools, and are resourceful in addressing minor technological issues.<sup>25</sup>

Khalaf et al. (2020) reported the opposite findings: staff (83%) were significantly more satisfied with the online exam than students. Faculty members' concerns focused on the time required to

TABLE 6 Faculty correlations (Kendal's tau).

Principal component	Gender	Age	# of courses taught	Overall assessment
1	$\tau=0.214, p=.235$	$\tau=-0.226, p=.138$	$\tau=-0.149, p=.370$	<b><math>\tau=0.625, p&lt;.001</math></b>
2	$\tau=-0.208, p=.249$	$\tau=0.222, p=.145$	$\tau=0.018, p=.916$	<b><math>\tau=-0.461, p=.006</math></b>
3	<b><math>\tau=0.507, p=.006</math></b>	$\tau=-0.137, p=.377$	$\tau=0.045, p=.791$	<b><math>\tau=0.392, p=.021</math></b>
4	$\tau=0.138, p=.467$	$\tau=-0.215, p=.177$	$\tau=0.337, p=.054$	<b><math>\tau=0.450, p=.010</math></b>
5	<b><math>\tau=0.400, p=.036</math></b>	$\tau=0.088, p=.584$	$\tau=-0.053, p=.764$	<b><math>\tau=0.447, p=.012</math></b>
Overall assessment	<b><math>\tau=0.416, p=.031</math></b>	$\tau=-0.177, p=.278$	$\tau=-0.005, p=.978$	

Statistically significant values are in bold.

TABLE 7 Correlations of students' answers to each question (Kendal's tau).

Question	Year of study	Overall assessment
1	$\tau=0.647, p=.394$	<b><math>\tau=0.460, p=000</math></b>
2	<b><math>\tau=0.168, p=.001</math></b>	<b><math>\tau=0.376, p=000</math></b>
3	$\tau=0.080, p=.136$	<b><math>\tau=0.492, p=000</math></b>
4	$\tau=0.042, p=.421$	<b><math>\tau=0.402, p=000</math></b>
5	$\tau=0.076, p=.146$	<b><math>\tau=0.535, p=000</math></b>
6	$\tau=0.038, p=.467$	<b><math>\tau=0.463, p=000</math></b>
7	$\tau=0.092, p=.080$	<b><math>\tau=0.663, p=000</math></b>
8	$\tau=-0.029, p=.572$	<b><math>\tau=0.429, p=000</math></b>
9	$\tau=0.090, p=.085$	<b><math>\tau=0.522, p=000</math></b>
10	$\tau=0.069, p=.189$	<b><math>\tau=0.477, p=000</math></b>
11	$\tau=0.012, p=.822$	<b><math>\tau=0.548, p=000</math></b>
12	$\tau=0.021, p=.683$	<b><math>\tau=0.577, p=000</math></b>
13	$\tau=0.090, p=.074$	<b><math>\tau=0.590, p=000</math></b>
14	$\tau=0.036, p=.494$	<b><math>\tau=0.460, p=000</math></b>
15	$\tau=0.010, p=.836$	<b><math>\tau=-0.477, p=000</math></b>
16	<b><math>\tau=-0.247, p=.000</math></b>	<b><math>\tau=0.277, p=000</math></b>
17	$\tau=0.055, p=.293$	<b><math>\tau=0.625, p=000</math></b>
18	$\tau=-0.109, p=.036$	<b><math>\tau=0.529, p=000</math></b>

Statistically significant values are in bold.

complete the exam set-up and grading compared to the paper-based exam as well as minor technological issues. By contrast, students highlighted issues of insufficient time and technology.<sup>14</sup> Similarly, Elsalem et al. (2021) reported that out of 730 students, only one-third preferred remote e-exams,<sup>28</sup> a result attributed to platform problems and increased stress. Shaiba et al. (2021) reported that medical students were significantly less satisfied with the quality of e-OSCE than their educators.<sup>19</sup>

Detection of gender differences revealed that female faculty were significantly more satisfied with online exams than their male colleagues. Shaiba et al. (2021) found no gender differences in the perceptions about the e-OSCE,<sup>19</sup> and Khalaf et al. (2020) reported no gender differences in both faculty and students' satisfaction with online assessment.<sup>14</sup> The increased overall satisfaction of female faculty may be related to their increased satisfaction in the two

principal components ('Faculty attitudes towards the exam procedures' and 'exam invigilation') which include questions referring to e-invigilation, choices of assessment tools and IT support. These are issues that could create stress, but they were successfully addressed during the exams.

It was of no surprise that students with previous experience in online exams (year 2-5) scored more positively than first-year students in all PCs, except in the 'Attitudes towards the technology used for the online exams' principal component. Similar results are reported in the literature,<sup>4,14,40</sup> where students who were experienced in online learning and assessment demonstrated more positive attitudes than the younger cohorts, who, although digitally knowledgeable, were novices in e-assessment. Being IT literate (as younger generations tend to be) does not imply that one would automatically be skillful in managing the challenges of online exams, which are conducted in a specific electronic environment, during a limited time, and with strict procedures and formalities to follow.

An important factor that emerged in this study was the support of the University to students and faculty, which we consider to be one of the two foundational pillars of e-assessment. As correctly stated, the sudden transition to e-learning and e-assessment due to the pandemic was catalytic in revealing the inadequacies in the technological infrastructure and human resources of the institutions, as well as the lack of training and teaching experience of educators.<sup>4,28</sup>

In the present study, the 'University support to faculty' component explained 15.7% of the total information (out of 75.5% interpreted by all five PCs) and includes the technical difficulties, the availability of the online exam coordinators, the time-consuming overall process, the difficulty in conducting the e-exams, the training manuals, webinars and mock exams. Unsurprisingly, there was a statistically significant negative correlation between this PC and overall faculty satisfaction. Increased satisfaction from the entire exam process largely depends on the adequate preparation and training of the academic staff, the IT support before and during the exams, and the tackling of technological problems. In our case, as EUC already had an operational IT Department, an LMS and all relevant resources for online learning, the faculty support proved to be timely and efficient. It is noteworthy that female and older faculty were significantly more satisfied with the support from the Dental School and the IT department of the University respectively. Similarly, it was reported that faculty who were trained in Blackboard Learn throughout the year

TABLE 8 Correlations of faculty answers to each question (Kendal's tau).

Questions	Gender	Age	# of courses taught	Overall assessment
1	$\tau = -0.013, p = .947$	$\tau = -0.155, p = .334$	$\tau = 0.345, p = .049$	$\tau = 0.107, p = .542$
2	$\tau = 0.197, p = .322$	$\tau = -0.294, p = .079$	$\tau = -0.021, p = .907$	$\tau = 0.658, p = .000$
3	$\tau = -0.177, p = .370$	$\tau = -0.390, p = .019$	$\tau = -0.0, 97, p = .595$	$\tau = 0.373, p = .042$
4	$\tau = -0.177, p = .364$	$\tau = -0.126, p = .442$	$\tau = -0.053, p = .764$	$\tau = 0.447, p = .012$
5	$\tau = -0.097, p = .613$	$\tau = -0.159, p = .327$	$\tau = -0.150, p = .405$	$\tau = 0.295, p = .103$
6	$\tau = -0.334, p = .097$	$\tau = -0.099, p = .559$	$\tau = -0.044, p = .803$	$\tau = 0.156, p = .383$
7	$\tau = -0.607, p = .001$	$\tau = -0.053, p = .738$	$\tau = -0.211, p = .256$	$\tau = 0.407, p = .029$
8	$\tau = -0.298, p = .119$	$\tau = -0.429, p = .008$	$\tau = -0.005, p = .978$	$\tau = 0.283, p = .107$
9	$\tau = -0.268, p = .159$	$\tau = -0.296, p = .065$	$\tau = -0.188, p = .287$	$\tau = -0.422, p = .017$
10	$\tau = -0.069, p = .715$	$\tau = -0.130, p = .418$	$\tau = -0.010, p = .956$	$\tau = -0.568, p = .001$
11	$\tau = -0.358, p = .073$	$\tau = -0.071, p = .672$	$\tau = -0.043, p = .806$	$\tau = -0.449, p = .011$
12	$\tau = -0.273, p = .144$	$\tau = -0.217, p = .169$	$\tau = -0.163, p = .375$	$\tau = 0.299, p = .106$
13	$\tau = -0.122, p = .515$	$\tau = -0.203, p = .201$	$\tau = -0.138, p = .423$	$\tau = 0.745, p = .000$
14	$\tau = -0.132, p = .490$	$\tau = -0.104, p = .519$	$\tau = -0.065, p = .707$	$\tau = 0.606, p = .001$
15	$\tau = -0.178, p = .350$	$\tau = -0.131, p = .417$	$\tau = -0.043, p = .808$	$\tau = 0.441, p = .013$
16	$\tau = -0.416, p = .031$	$\tau = -0.177, p = .278$	$\tau = -0.206, p = .701$	$\tau = 0.529, p = .000$

were very satisfied with the online exams.<sup>14</sup> Moreover, a University's educational and technical support is crucial in reducing the time required by the staff to organise and conduct the online exams, as these are considered more time-consuming than traditional paper-based exams (considering setting up, uploading questions, reporting and student accessibility). Indeed, the majority of the EUC academic staff (mean 3.67, Question 16) answered that online exams are more time-consuming than traditional ones. This was also reported as a major concern of faculty members in another study.<sup>14</sup> Consistent with these findings, the educational and technical University support was negatively correlated with the time-consuming issue.

On the other hand, the 'University support to students' principal component explained most of the total information (42.6% out of 60.6% interpreted by all four PCs) and includes the availability of the online exam coordinators and the IT department, the clear instructions, the educational platforms and the Respondus e-invigilation system, the training manuals, webinars and mock exams. It seems that students highly appreciated the support offered by the institution and their educators, particularly the clear instructions, communication and guidance.<sup>19</sup> Students expect unlimited, continuous support and guidance from their instructors during their studies and especially during the exam period.

Students' stress can be considered the other pillar of e-assessment. Anxiety regarding exams has been described before and associated with low student confidence and low exam performance,<sup>15,41</sup> in addition to a negative impact on students' physical and mental health and well-being (dietary habits, sleep disorders, smoking, less physical exercise).<sup>42</sup> Reduced stress during online exams, similar to that of paper-based exams, has also been reported.<sup>16,19</sup>

Contributing factors to increased stress are technical problems<sup>17,29,42</sup> including internet connection,<sup>41,5</sup> unstable exam platforms,<sup>28,42</sup> unfamiliar technologies and tools,<sup>43</sup> environmental distractions,<sup>4</sup> linear presentations of the exam content, not permitting

an overview<sup>23,42</sup> and exam duration.<sup>42</sup> Indeed, approximately one in four students (mean 2.42, Question 13) reported technical problems that affected their performance, whereas an overwhelming majority felt that the exam duration was sufficient (mean 4.33, Question 16), and this applies more to the less experienced students, as the question about the exam duration was negatively and significantly correlated with the study year. It seems that first-year students—novices and inexperienced, yet possessing self-awareness and determination to succeed—were better prepared for the exams and more efficient in time management, than the experienced—possibly overconfident—students. Despite the technical difficulties mentioned, the fourth principal component 'Attitudes towards the technology used for the online exams' was statistically and significantly negatively correlated with the overall satisfaction of students; therefore, the technical failures did not affect their overall positive perception. Training ahead of the online exam on its structure and methodology and conducting an online mock exam are considered protective factors to student stress.<sup>14,15,42</sup> This is in agreement with our findings, where the large majority of students felt that training and mock exam were adequate to familiarize them with the exam (mean 4.43, Question 3) and these initiatives made them less anxious (mean 4.06, Question 4). From the faculty point of view, stress was perceived as higher in online exams than in traditional ones (mean 3.29, Question 11), explained by the digital challenges, the increased working time, the technological uncertainties and related issues, as already mentioned.

Another issue deserving particular attention is the e-invigilation systems used in online exams to prevent cheating and preserve academic honesty. A variety of systems and combination of methods has been used to ensure academic integrity during the online exams: privacy screen filters for on-site exams,<sup>30</sup> ExamID and ExamMonitor to confirm student identities and to video-audio monitor them,<sup>43</sup> signed Ethics Pledge in combination with Zoom videoconferencing application (Zoom Communications Inc., San Jose, CA, USA) and with 'cheating behaviour

lists,<sup>32</sup> face-tracking movement and artificial intelligence,<sup>31,32</sup> random question sequencing and shuffling in the order of choices.<sup>28,32</sup>

To prevent cheating, EUC applied the random shuffling of both questions and answers by the software in combination with the Respondus Monitor and LockDown Browser proctoring system, a system widely used in remote exams.<sup>14,20,25</sup> The exams took place at students' homes, which is a preferred location for taking online exams.<sup>20</sup> Almost half of the faculty (only) in this study thought that Respondus browser was reliable and prevented cheating (mean 3.00, Question 4), whereas most students thought that it prevented cheating (mean 4.02, Question 18). In addition, the majority of faculty members replied that they constantly checked the high-alert video recordings (mean 3.88, Question 5) with the aim to identify cheating attempts. In an effort to explain these findings regarding the efficiency of e-invigilation, we could assume that educators considered that students were capable to cheat despite the e-invigilation barriers (thus many educators considered the proctoring system as unreliable), while students actually could not cheat or were not willing to (thus the majority considered it as reliable). Elsaleh et al. (2021) asked students whether they have had any exam misconduct and dishonesty during the online exams. Approximately 55% of the students reported no exam dishonesty, while the other half sought assistance from friends or other sources.<sup>28</sup> The acceptance of e-invigilation was high among the EUC students (mean 4.13, Question 9), a finding that is consistent with previous studies (90% acceptance rate in the study of Escudier et al.).<sup>30</sup>

Despite the positive perceptions of students and the apparent usefulness of remote supervision, concerns are raised in relation to basic students' rights, privacy intrusion, stress induction and their emotional needs.<sup>20,31,43</sup> Indeed, a sizeable number of EUC students stated that they felt uncomfortable with the Respondus browser (mean 2.41, Question 8). To address these concerns, Silverman et al. (2021) in their study argued against remote invigilation, advocated for equity, and proposed authentic assessments in addition to investing in instructional designers and faculty development programs.<sup>44</sup>

Assessment is an integral part of the learning process, reflective of the quality of education provided. Therefore, dental institutions should thoughtfully decide on their digital assessment practices, taking into consideration their educational needs, academic integrity, technological challenges and opportunities and their staff and students' well-being. As concluded already, the development, delivery and quality assurance of assessments is a challenging task for educators and institutions and requires significant financial and human resources.<sup>39</sup>

## 5 | CONCLUSIONS

The present study explored—through questionnaires—the perception of dental undergraduate students and dental faculty on online exams with e-invigilation and identified key factors influencing these perceptions. In general, perception relates to previous experiences and preparatory training, technical parameters, support from the University IT services and from the designated exam coordinators, efficiency and reliability of the remote invigilation, flexibility,

availability and clarity of the software, and personal attributes (time management, stress, responsibility). The overall satisfaction with the exams of both students and staff was high, with female faculty members being significantly more satisfied than their male colleagues. Students with previous experience in online exams (years 2–5) answered more positively than first-year students. University support to staff and students (training, IT support, resources) emerged as an important element of the exams. The majority of the EUC academic staff thought that online exams are more time-consuming than traditional ones, but University support can mitigate this. Another important element is student stress, attributed—among other factors—to technical problems; nevertheless, technical failures did not affect their overall positive perception. Training ahead of the online exam and conducting a mock exam are considered protective factors against student stress. E-invigilation seems necessary to ensure academic integrity, but students more than educators perceive it as efficient. The vast majority of students consider e-invigilation as an acceptable method, although some of them felt uncomfortable with the remote monitoring throughout the exam duration.

## CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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## APPENDIX 1

### Questions included in principal components for students' answers.

#### First Principal Component—University support to students

- I was satisfied with the accessibility and availability of the online exam coordinators (in the Department of Dentistry) to solve any issues before and during the exam.
- Exam instructions were clearly addressed to me.
- I was satisfied with the accessibility and availability of the IT Department (MIS) of the University to solve any issues before and during the exam
- The training manuals, webinars and the mock exams for the online exam were adequate to familiarise me with the exam.
- I was satisfied using Moodle and Respondus for the online examination.
- I feel Respondus lockdown browser was an acceptable method to invigilate the online exams.

#### Second Principal Component—Comparison between online and face-to-face exams

- Online exams are more flexible and accessible than paper-based exams.
- Online exam's marking is more reliable since there is no human error.
- I feel that e-invigilation with Respondus lockdown browser was not giving a chance to cheat.
- My online exam grade reflects my performance.
- I enjoyed the features of the software used in online exams.

#### Third Principal Component—Preparation for the online exams

- The online exam duration was sufficient.
- The training and the mock exam received made me feel less anxious about the online exam.
- I have adequate previous experience in an online learning system (e.g. Moodle, Blackboard, MS Teams, Zoom, etc.)

#### Fourth Principal Component—Attitudes towards the technology used for the online exams

- I felt uncomfortable with the Respondus lockdown browser for e-invigilation
- Online assessments favour some students more than others.
- Technical problems such as internet connection issues or computer crashes affected my performance in the online exam.
- The technology used in online assessments is reliable.

## APPENDIX 2

### Questions included in principal components for faculty answers.

#### First Principal Component—Comparison between online and face-to-face exams

- Online exams are more flexible and accessible than paper-based exams.

- Overall, I prefer online exam grading in comparison with the paper-based grading.
- The technology used for setting and administering the online exam was reliable.
- The online exam made the students and the Faculty more anxious than in the traditional setting.

#### Second Principal Component—University support to faculty

- I faced significant technical difficulties setting up the online exam.
- It was more difficult for me to conduct the online exam than in the traditional setting.
- The training manuals, webinars and mock exams for the online exam were adequate to familiarise myself with the exam set-up.
- I feel that online exam is totally more time-consuming than traditional face-to-face exam (taking into account setting up, uploading questions, grading, reporting and student accessibility).
- I was satisfied with the accessibility and availability of the online exam coordinators (in the Department of Dentistry) to solve any issues before and during the exam.

#### Third Principal Component—Faculty attitudes towards the exam procedures

- I checked all high alerts, most medium alerts and a few low-alert recordings provided by Respondus lockdown browser.
- In order to detect students that were cheating, I checked carefully and watched all high-alert video recordings provided by Respondus lockdown browser.
- The possibilities offered by the online exam platform (e.g. different percentage marking for each answer, ability to upload pictures and X-rays, the combination of single correct answer with multiple correct answers) were significant tools in the student assessment.
- I was satisfied with the accessibility and availability of the IT Department (MIS) of the University to solve any issues before and during the exam.

#### Fourth Principal Component—Human factors associated with the exam procedures

- Before the online exams, I had adequate previous experience in online learning systems (e.g. Moodle, Blackboard, MS Teams, Zoom, etc.).
- Online exam's marking is more reliable since there is no human error.

#### Fifth Principal Component—Exam invigilation

- The method used for invigilating the exam (Respondus lockdown browser) was reliable and actually prevented cheating.