Perceptions of e-learning among Tunisian medical students during the COVID-19 pandemic: Strategies for effective implementation in medical education

Perceptions de l'apprentissage en ligne parmi les étudiants Tunisiens en médecine pendant la pandémie de la COVID-19: Stratégies pour une mise en œuvre efficace dans l'enseignement médical

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ABSTRACT

Aims: In Tunisia, during the Coronavirus Disease 19 pandemic, the transition to e-learning was brutal. The aim of this study was to assess undergraduate medical students (UMSs)' perception of the e-learning experience at the Faculty of Medicine of Sousse, and to derive some determinants of its implementation.
Methods: Eligible participants were all UMSs (n=1397). The data was collected from an email questionnaire distributed in January/March 2021. The questionnaire consisted of 89 items exploring three main parameters: institution role, students' personal experience, and environment impact.
Results: A total of 419 UMSs responded (30% response rate). Half of the UMSs described this transition as difficult, and three-quarters felt concerned about the credibility of their degrees. Logistical issues negatively affected the transition to e-learning, particularly those related to Internet speed. Understanding difficulty via the screen interface was reported by 40% of UMSs. ''Face-to-face'' sessions were described as more conducive to assimilation by 64% of UMSs. As far as "information retrieval" is concerned, 83% of UMSs turned to social networks and adopted Wikipedia as a reference.
Conclusions: In Tunisia, as an example of North African country, the transition to exclusive e-learning has been largely impacted by the drawbacks of limited logistics. This study highlights the multiple facets to be considered in the future for the successful implementation of e-learning in medical education.

Key words: COVID-19; E-Learning; Health sciences; Low and middle-income country; Medical student

RÉSUMÉ

Objectifs: En Tunisie, durant la pandémie de la maladie à coronavirus 2019 (COVID-19), la transition vers l'apprentissage en ligne a été brutale. Cette étude visait à évaluer la perception des étudiants en médecine de premier cycle (EMPC) concernant l'expérience d'apprentissage en ligne à la Faculté de Médecine de Sousse, et à identifier certains déterminants de sa mise en œuvre.
Méthodes: Les participants éligibles étaient tous les EMPC (n=1397). Les données ont été recueillies à l'aide d'un questionnaire envoyé par e-mail entre janvier et mars 2021. Le questionnaire comportait 89 items explorant trois principaux paramètres: rôle de l'institution, expérience personnelle des étudiants, et impact de l'environnement.
Résultats: Un total de 419 EMPC a répondu (taux de réponse de 30%) au questionnaire. La moitié des étudiants a décrit cette transition comme difficile, et trois quarts se sont inquiétés de la crédibilité de leurs diplômes. Les problèmes logistiques, en particulier liés à la vitesse d'Internet, ont négativement impacté la transition vers l'apprentissage en ligne. Une difficulté de compréhension via l'interface écran a été rapportée par 40% des étudiants. Les sessions «en présentiel» ont été décrites comme plus propices à l'assimilation par 64% des étudiants. Concernant la «recherche d'information», 83% des étudiants ont utilisé les réseaux sociaux et adopté Wikipédia comme référence.
Conclusions: En Tunisie, à titre d'exemple de pays d'Afrique du Nord, la transition vers un apprentissage exclusivement en ligne a été largement affectée par les limites logistiques. Cette étude met en lumière les multiples aspects à considérer à l'avenir pour une mise en œuvre réussie de l'apprentissage en ligne dans l'enseignement médical.

Mots clés: Apprentissage en ligne ; COVID-19 ; Étudiants en médecine ; Pays à revenu faible et intermédiaire ; Sciences de la santé

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INTRODUCTION

The coronavirus disease 19 (COVID-19) pandemic has had a devastating impact on the education sector at all levels (1,2). On November 20, 2022, the United Nations Educational, Scientific, and Cultural Organization described the period of the pandemic as "disruptive", as it led to the closure of three-quarters of educational institutions for more than 41 weeks, affecting over 70% of students worldwide (3). While already embraced in several higher education disciplines (4), the call for e-Learning in medicine, especially in its "exclusive" form, has generated more than reluctance; it has presented a formidable challenge for educational institutions (2). Indeed, grounded in the principle of 'face-to-face' interaction and human integration across multiple dimensions, including psychological ones, medical learning was not yet prepared to be entirely supplanted by the e-Learning model (2).

In Tunisia, a lower middle-income country (LMIC) in North Africa, the impacts of the COVID-19 pandemic have been pernicious (5,6). With one of the highest mortality rates globally (7,8), and delays in the vaccination campaign (6), managing the academic years 2020-2021 and 2021-2022 was a difficult "feat" (9). The latter was marked by multiple unplanned interruptions, namely three lockdown episodes (i.e. March 18 to April 4, 2020 (10), May 9 to 16, 2020 (11), and January 13 to 24, 2021 (12)). The absence of a medium-long-term strategic plan and government decisions largely depended on the changing health conditions (10,11). In this context of uncertainty, the use of e-Learning was not a choice, but an obligation that nevertheless ushered medical education into the e-Learning era (1). To the best of the authors' knowledge, no such evaluation has been carried out in the Tunisian or Maghrebian medical schools.

The objective of this study was to assess the transition experience of Faculty of Medicine of Sousse (FMSo) to e-learning during the COVID-19 pandemic, and to identify the factors that ensure the successful implementation of future e-learning initiatives.

METHODS

Study design

This was a cross-sectional survey performed from January 12, 2021 to March 16, 2021 of the academic year 2020-2021. This study received prior approval from the FMSo's administration, which provided the first author with the emails and phone numbers of 1397 undergraduate medical students (UMSs) enrolled in the first (FCMS) and second (SCMS) cycles of medical studies for the 2020-2021 academic year [FCMS1 (1st year, n=294), FCMS2 (2nd year, n=281), SCMS1 (3rd year, n=283), SCMS2 (4th year, n=274), and SCMS3 (5th year, n=265)]. The FMSo Institutional Ethics Committee found no ethical concerns with the study if participation remained anonymous, voluntary, and free from any pressure.

An information form explaining the aims of the study was attached electronically to the set of questionnaires (Appendix 1). Details were communicated to the delegates of the different classes and posted on the login page of the questionnaire. In Tunisia, medical education is conducted in French (Appendix 1). Therefore, all survey tools were written in French. Clicking the "start" button displayed on Google Forms indicated the UMS's consent to participate in the study. Short message service (SMS) messages were sent to UMSs from the institution's database. The first author, a professor of physiology, was the sole manager of the UMSs list and the database including their responses. The confidentiality and anonymity of all SMS messages was ensured throughout the study. The survey was created in Google Forms, and its initial distribution was planned by SMS. Depending on the evolution of the participation rates, reminders via Facebook groups were considered by contacting the different promotion delegates. Figure 1 presents the study design.
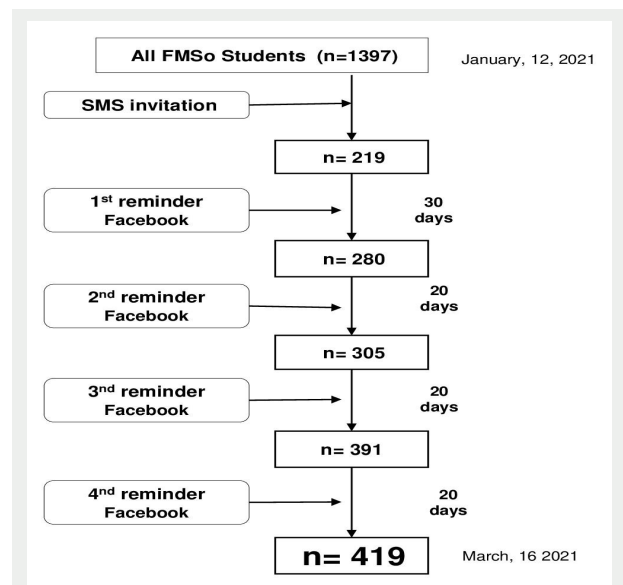

Figure 1. Study flowchart.
FMSo: Faculty of medicine of Sousse. **SMS**: Short message service.

Population

The invitations to participate were sent to all UMSs in FMSo without any restrictions. The inclusion criteria were UMSs aged over 18, enrolled at FMSo during the 2020-2021 academic year, and who consented to participate.

Survey

The survey was based on the implementation of a new French questionnaire (Appendix 1) due to the lack of a validated measurement tool available on this topic. The questions were 'inspired' by a literature review conducted on Medline (1,13-16). The questionnaire's structure was built upon three parameters that formed the research axes, which were the institution, UMSs, and environment. The questionnaire consisted of 89 mandatory items and was administered via Google Forms. The form was configured to allow only one response per participant, and UMSs could not skip any questions. This setup

effectively prevented duplicate entries and ensured the completeness of the data. At the end of each section, the questionnaire included open-ended response options, allowing UMSs to freely share their personal experiences or suggestions. UMSs responded to questions using the 5-level Likert satisfaction scale (1: strongly disagree, 2: disagree, 3: undecided, 4: agree, 5: strongly agree) (17). The questionnaire took about 20 minutes to complete.

Sample size and statistical analysis

The estimated sample size was calculated using the Raosoft online sample size calculator (18), with a 95% level of significance. The largest required sample size was 419. For statistical reasons, the responses "strongly disagree" and "disagree" were combined as "disagree" (i.e. unfavorable opinion), while, the responses "agree" and "strongly agree" were combined as "agree" (i.e. favorable opinion). The frequencies of responses to all Likert scale items were reported in detail in the tables. Cronbach's alpha was not calculated because each item represented a unique context. Associations between UMSs' characteristics and responses were examined using a two-tailed chi-square test.

For the analyses, Statistica-12 (StatSoft, TIBCO Software Inc. 2014) was used. The significance level was set at 0.05.

RESULTS

After the initial SMS invitation, 219 (16%) responses were recorded. Following four reminders, the final response rate was therefore 30% (= 419/1379, Figure 1).

Characteristics of UMSs

The highest response rates were among the UMSs in the FCMS1 and FCMS2: 22% and 34%, respectively (Figure 2). Of the UMSs enrolled in the FMSo, 61.2% had residency outside the city of Sousse (other governorates or foreign students). However, during the lockdown periods, 83.9% of UMSs were with their families.
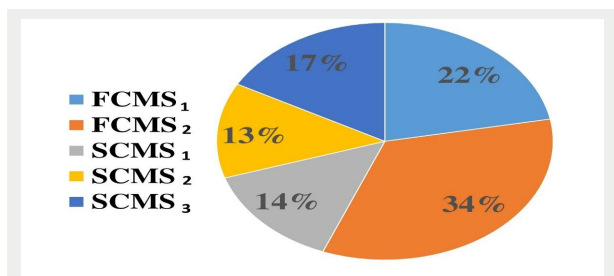

Figure 2. Distribution of response rates based on promotions
FCMS1: 1st cycle of medical student (1st year).
FCMS2: 1st cycle of medical student (2nd year).
SCMS1: 2nd cycle of medical student (3rd year).
SCMS2: 2nd cycle of medical student (4th year).
SCMS3: 2nd cycle of medical student (5th year).

UMSs' perception of the institution's role

The perceptions of UMSs regarding faculty roles during the COVID-19 crisis revealed mixed feedback. While they acknowledged the transition as "difficult," primarily due to poor Internet quality, interactive activities like quizzes and forums were appreciated. Scheduling and course management on the "ent.uvt.rnu.tn" platform were deemed "unsatisfactory" and videoconferencing posed challenges due to technical issues and unfamiliarity. Despite recognizing teachers' efforts and the administration's material support, students noted the absence of psychological assistance and regular communication, which led to frustration, including the lack of a health situation newsletter and strategic guidance (Table 1).

UMSs' perception of their e-Learning experience

UMSs had an overall negative perception of exclusive e-Learning during the pandemic, mainly due to the lack of "face-to-face" interaction and difficulties in managing workloads. The flexibility of e-Learning was not beneficial for those with family or work obligations. Interaction on the Moodle platform was minimal, as students found it "conventional" and shifted to social media for discussions. As a result, "ent.uvt.rnu.tn" lost its status as a primary learning source, with students preferring alternative sites like Wikipedia. While e-Learning wasn't deemed a "waste of time," opinions on its future were mixed, with strong support for maintaining in-person learning as essential (Tables 2 and 3).

UMSs' perceptions of the environment role

Open-ended responses in French, translated into English are reported in Appendix 2. These responses reflect the negative psychological impacts of the COVID-19 crisis on UMSs, describing mental suffering aggravated by isolation and uncertainty about the future of medical training in the medium- and long- terms.

DISCUSSION

This study was conducted to evaluate the e-Learning transition experience at a medical school in a North-African LMIC (Tunisia) during the COVID-19 pandemic.

The main results of this study were: i) 50% of the UMSs described the transition to e-Learning as difficult, with 75% expressing concerns about the credibility of their degrees; ii) Logistical issues, particularly related to Internet speed, negatively impacted the transition to e-Learning; iii) 40% of UMSs reported difficulty understanding via the screen interface; iv) ''Face-to-face'' sessions were described as more conducive to assimilation by 64% of UMSs; and v) Regarding "information retrieval", 83% of UMSs turned to social networks and adopted Wikipedia as a reference. Three main parameters that influenced UMSs satisfaction were related to the institution (e.g. logistics in particular), student (e.g. preferences in teaching methods), and the environment (e.g. psychological impact of the pandemic). The interactions between these parameters were complex.

Table 1. Student's perception regarding the role of the institution (n=419).

Items	Unfavorable opinion		Undecided	Favorable opinion		p-value
	Strongly disagree	Disagree		Agree	Strongly agree	
Managing material resources						
1. Overall, my faculty was able to adapt quickly to e-Learning	45 (11)	97 (23)	112 (27)	111 (27)	53 (13)	0.111
2. I felt this adaptation was difficult	42 (10)	67 (16)	91 (22)	99 (24)	119 (28)	<0.001*
3. Logistical organization (Wi-Fi, teaching rooms, computer layout...) was satisfactory	84 (20)	98 (23)	137 (33)	69 (16)	30 (7)	<0.001*
4. The majority of teachers used softwares predefined by faculty (no installing problems)	29 (7)	50 (12)	118 (28)	112 (27)	109 (26)	<0.001*
5. Scheduling was adequate and not perceived as overload of work	88 (21)	107 (26)	92 (22)	89 (21)	42 (10)	<0.001*
6. The availability of course materials was satisfactory (no delay, no missing)	77 (18)	96 (23)	86 (21)	96 (23)	63 (15)	0.329
7. The different formats of course materials (pdf, word, ppt) didn't bother me	35 (8)	61 (15)	103 (25)	109 (26)	110 (26)	<0.001*
8. I would have liked a more unified format of course materials	18 (4)	25 (6)	66 (16)	81 (19)	228 (54)	<0.001*
9. Activities (such as self-assessment quizzes) helped me to better understand	32 (8)	32 (8)	93 (22)	125 (30)	136 (32)	<0.001*
10. Generally, used tools (activities, videos, etc.) were consistent with the course content	18 (4)	29 (7)	93 (22)	151 (36)	127 (30)	<0.001*
Managing human resources						
11. The faculty has provided a technical service that was quickly and easily accessible	81 (19)	98 (23)	142 (34)	62 (15)	35 (8)	<0.001*
12. The majority of teachers had tried to make more effort than usual to facilitate our understanding (**eg**: lengthening the session to answer questions, highlighting important points on provided documents, etc.)	41 (10)	65 (16)	99 (24)	116 (28)	97 (23)	<0.001*
13. The majority of teachers had provided a way to contact them (e-mail addresses, forum, etc.)	131 (31)	126 (30)	97 (23)	41 (10)	23 (5)	<0.001*
14. The majority of teachers responded to the predetermined objectives of courses	23 (5)	65 (16)	123 (29)	127(30)	80 (19)	<0.001*
15. The majority of teachers provided video-conferences sessions	71 (17)	77 (18)	119 (28)	91 (22)	60 (14)	0.809
16. The majority of teachers were well prepared to handle e-Learning tools	106 (25)	117 (28)	118 (28)	55 (13)	22 (5)	<0.001*
17. The majority of teachers were comfortable and able to establish easy contact with their students through the screen	98 (23)	116 (28)	111 (27)	58 (14)	35 (8)	<0.001*
18. The management of the video-conference sessions was fluid without loss of time (no internet cuts, no problems of students management)	176 (42)	91 (22)	90 (21)	43 (10)	18 (4)	<0.001*
19. During e-Learning session, the majority of teachers regularly checked our understanding before moving to another point	44 (10)	56 (13)	118 (28)	113 (27)	87 (21)	<0.001*
20. The majority of teachers encouraged us to ask questions	16 (4)	45 (11)	91 (22)	126 (30)	140 (33)	<0.001*
21. When we ask questions, the majority of teachers took the time to answer and give us sufficient explanations	10 (2)	24 (6)	109 (26)	153 (37)	122 (29)	<0.001*
22. This has not always been possible because time was limited	52 (12)	70 (17)	102 (24)	93 (22)	101 (24)	<0.001*
23. It was difficult for me to follow because everyone was talking at the same time	95 (23)	98 (23)	89 (21)	58 (14)	78 (19)	<0.001*
The social role of faculty: assistance and support						
24. The faculty took great care of training and preparing students for e-Learning transition	70 (17)	95 (23)	117 (28)	86 (21)	50 (12)	0.040*
25. The faculty helped students in financial difficulty acquire the necessary equipment	42 (10)	50 (12)	180 (43)	78 (19)	68 (16)	<0.001*
26. The faculty assisted students who expressed difficulties in adapting	57 (14)	78 (19)	159 (38)	79 (19)	45 (11)	0.415
27. I felt that my faculty was close to us during this crisis	77 (18)	89 (21)	119 (28)	79 (19)	54 (13)	0.017*
28. Our faculty ensured that we were kept regularly informed of developments in sanitary situation and the new arrangements to be adopted	79 (19)	83 (20)	121 (29)	82 (20)	53 (13)	0.049*
29. Our faculty ensured to have news of all students. especially those who did not come forward	137 (33)	98 (23)	114 (27)	45 (11)	24 (6)	<0.001*
30. I have known cases of students who were in difficulty (social, material), who asked for assistance but didn't get any answer from the administration	193 (46)	66 (16)	123 (29)	22 (5)	14 (3)	<0.001*
31. I have known cases of students who were facing difficulties (social, material), who requested assistance and who were taken care of either by the administration or by the support committees attached to my faculty.	128 (30,7)	47 (11,3)	157 (37,6)	52 (12,5)	33 (7,9)	<0.001*
32. I have known cases of students who have dropped out because of this crisis	231 (55)	36 (9)	73 (17)	32 (8)	46 (11)	<0.001*

Data were number (%). *p-value < 0.05: two sided chi-2 test: unfavorable (strongly disagree and disagree) vs. favorable (agree and strongly agree) opinions.

Table 2. Student's perception of their e-Learning experience (n=419).

Items	Unfavorable opinion		Undecided	Favorable opinion		p-value
	Strongly disagree	Disagree		Agree	Strongly agree	
Perception of e-Learning experience in the pandemic context						
33. My expectations have been fully met	119(28)	95(23)	85(20)	65(16)	54(13)	<0.001*
34. I feel satisfied with my ability to adapt quickly	57(14)	53(13)	101(24)	128(31)	79(19)	<0.001*
35. Organizing my schedule did not seem more difficult	83(20)	64(15)	122(29)	78(19)	71(17)	<0.001*
36. I did not feel «overworked»	122(29)	103(25)	86(21)	50(12)	57(14)	<0.001*
37. I struggled more than usual to organize my self	61(15)	61(15)	67(16)	61(15)	168(40)	<0.001*
38. E-Learning did not impact the quality of my learning	164(39)	62(15)	75(18)	55(13)	62(15)	<0.001*
39. I was able to participate in the video-conferencing sessions by asking questions and speaking as if it were a regular face to face sessions	114(27)	78(19)	89(21)	62(15)	75(18)	<0.001*
40. Understanding transmitted messages via the screen did not seem more difficult to me	77(18)	76(18)	94(22)	97(23)	74(18)	0.201
41. E-learning has hampered my active participation	82(20)	65(16)	80(19)	72(17)	119(28)	0.002*
42. I regret the lack of direct interaction with my teachers and colleagues	59(14)	40(10)	71(17)	60(14)	188(45)	<0.001*
43. Digital tools cannot match the presence of our teachers	47(11)	42(10)	60(14)	57(14)	212(51)	<0.001*
44. E-learning cannot replace 'face to face' sessions and clinical practice	46(11)	31(7)	52(12)	66(16)	223(53)	<0.001*
45. I miss the 'face to face' sessions	71(17)	30(7)	52(12)	60(14)	205(49)	<0.001*
46. E-learning is ineffective and not suitable for medical education	101(24)	46(11)	78(19)	74(18)	119(28)	0.001*
Pre-pandemic student's behavioral						
47. I usually avoid coming forward	54(13)	53(13)	120(29)	86(21)	105(25)	<0.001*
48. I usually avoid participating, I just listen to other people's comments	92(22)	65(16)	102(24)	78(19)	81(19)	0.881
49. I'm a bit afraid of to intervene in front of everyone	87(21)	58(14)	86(21)	77(18)	110(26)	0.003*
50. When the teacher is nice. this encourages me to participate	7(2)	5(1)	54(13)	91(22)	261(62)	<0.001*
51. This has nothing to do with teacher, if I want to ask a question. I do it	91(22)	107(26)	100(24)	49(12)	71(17)	<0.001*
Student's behavior towards Moodle platform						
52. My involvement in activities (forum, quiz) was regular	82(20)	89(21)	124(30)	76(18)	47(11)	<0.001*
53. In fact, I was involved in these activities only in the approach of the exam	46(11)	53(13)	132(32)	110(26)	77(18)	<0.001*
54. My main motivation for participating in these activities is passing the exam (know the profile of questions that can be asked)	22(5)	36(9)	101(24)	118(28)	141(34)	<0.001*
55. If the content of these activities doesn't bring me one more to the examination, honestly, I will not consult it because I consider it a waste of time	40(10)	61(15)	105(25)	86(21)	126(30)	<0.001*
56. I ask a lot of questions on forum spaces	271(65)	91(22)	37(9)	11(3)	8(2)	<0.001*
57. On forum spaces, I only consult the questions of others and the answers of teachers	50(12)	32(8)	103(25)	102(24)	131(31)	<0.001*
58. I avoid putting questions on my behalf because I'm afraid of my teachers and colleagues' judgement	167(40)	58(14)	89(21)	41(10)	63(15)	<0.001*
59. When I have a question or a point to clarify. it is easier to address my colleagues than my teachers through the platform	31(7)	36(9)	82(20)	98(23)	171(41)	<0.001*
60. I use other discussion spaces with my colleagues than uvt.tn, such as Facebook and Messenger	42(10)	18(4)	59(14)	103(25)	196(47)	<0.001*
61. Our discussions on these spaces are rich and lively and allow me to hear from them in real time	42(10)	32(8)	81(19)	113(27)	150(36)	<0.001*
62. I am much more comfortable in these private spaces than on the uvt.tn site	31(7)	20(5)	78(19)	89(21)	200(48)	<0.001*
63. The discussion spaces on uvt.tn are exposed to all. are property of faculty, have no interactive interface and the teacher's responses are often slow to come	20(5)	26(6)	138(33)	91(22)	143(34)	<0.001*
64. When I search for information, I go to Wikipedia or the documents available on Google because it is quick and easier than medicine reference books	7(2)	8(2)	57(14)	85(20)	261(62)	<0.001*
65. This happens more than half the time	10(2)	29(7)	85(23)	96(23)	198(47)	<0.001*
66. This happens rarely (I always look for information in references)	149(36)	112(27)	90(21)	41(10)	26(6)	<0.001*
E-learning future in medical education						
67. E-learning is waste of time	144(34)	69(16)	74(18)	57(14)	74(18)	<0.001*
68. E-learning should be the predominant method in teaching	164(39)	70(17)	62(15)	44(10)	78(19)	<0.001*
69. E-learning should be considered with more interest	97(23)	68(16)	73(17)	66(16)	114(27)	0.289
70. E-learning is good, but 'face to face' must remain an essential foundation	29(7)	35(8)	52(12)	70(17)	232(55)	<0.001*

Data were number (%). *p-value < 0.05: two sided chi-2 test: unfavorable (strongly disagree and disagree) vs. favorable (agree and strongly agree) opinions.

Table 3. Students' perceptions of the environment role (n=419).

Items	Unfavorable opinion		Undecided	Favorable opinion		p-value
	Strongly disagree	Disagree		Agree	Strongly agree	
Experience of e-Learning transition in pandemic context						
71. At beginning, I was afraid of this experience	47(11)	53(13)	68(16)	75(18)	175(42)	<0.001*
72. This anxiety is over now	89(21)	84(20)	101(24)	59(14)	85(20)	0.036*
73. I was quickly reassured as I was sure to find assistance from my faculty	92(22)	111(27)	120(29)	66(16)	29(7)	<0.001*
74. Rather, I had found assistance from my colleagues	33(8)	59(14)	120(29)	127(30)	79(19)	<0.001*
75. I felt isolated and 'abandoned', especially during periods of confinement	78(19)	55(13)	91(22)	70(17)	124(30)	<0.001*
76. Not seeing and interacting with my colleagues was stressful	82(20)	62(15)	74(18)	66(16)	134(32)	<0.001*
77. I have maintained my regular contact with colleagues	48(11)	94(22)	118(28)	94(22)	64(15)	0.251
78. My presence in faculty was a motivation to engage in learning	51(12)	29(7)	66(16)	63(15)	209(50)	<0.001*
79. I feet than e-Learning is tacking me away from student life	53(13)	51(12)	52(12)	60(14)	202(48)	<0.001*
80. I was afraid of losing the rhythm and the desire to study	75(18)	44(10)	37(9)	54(13)	208(50)	<0.001*
Social context of those working or with dependent family						
81. My responsibilities made it difficult to focus on e-Learning	64(19)	58(17)	91(26)	58(17)	73(21)	0.435
82. Due to my responsibilities, I could not always be present and active during the e-Learning sessions	64(19)	78(23)	71(21)	61(18)	70(20)	0.328
83. Thanks to its flexibility, e-Learning has helped me a lot	72(21)	59(17)	71(21)	58(17)	84(24)	0.343
Fears for the quality of training						
84. I feel anxious about the gaps in my training	28(7)	20(5)	59(14)	64(15)	247(59)	<0.001*
85. I feel anxious about ways of catching up (during summer/holidays)	14(3)	21(5)	61(15)	63(15)	259(62)	<0.001*
86. I feel anxious about the credibility of my medical degree	33(8)	27(6)	56(13)	54(13)	248(59)	<0.001*
Suggestions to exit from the crisis						
87. Further strengthening e-Learning to ensure the safety of all	89(21)	49(12)	83(209)	56(13)	141(34)	<0.001*
88. Find the right formulas to restore practical learning, despite the sanitary crisis	42(10)	36(9)	69(16)	61(15)	210(50)	<0.001*
89. Do not exclude students and think about training them to deal with such circumstances	49(12)	34(8)	82(20)	52(12)	201(48)	<0.001*

Data were number (%). *p-value < 0.05: two sided chi-2 test: unfavorable (strongly disagree and disagree) vs. favorable (agree and strongly agree) opinions.

Institution parameters

The transition to e-Learning depends significantly on effective logistics and planning, with Internet quality being a global challenge (19). Implementing e-Learning comes with substantial costs (19), including continuous maintenance and updates, which can be particularly burdensome for LMICs despite the potential benefits for accreditation and international rankings (19). This issue affects both developed nations (20) and LMICs alike (19), posing consistent barriers to seamless e-Learning implementation.

Students prefer uniform and standardized teaching resources to support effective learning, but an overabundance of materials can become overwhelming (21). To meet student expectations and uphold institutional appeal, effective management should focus on developing consistent, high-quality resources (21). Although diverse resources can aid comprehension, an excessive number can create confusion and hinder the learning process (22).

The COVID-19 pandemic intensified organizational challenges, with teachers juggling hospital, university, and personal responsibilities, and students experiencing overwork and poorly structured schedules (20). Unexpected lockdowns and strikes further disrupted classes, complicating planning and negatively affecting student organization (19). To prevent disengagement and demotivation, strong planning, teacher training, and technical support are crucial. Effective communication and a pre-established crisis strategy are also vital for cohesive responses, as poor communication can lead to student frustration (20). This study highlights the institution's moral obligation to balance educational delivery with social care.

Handling digital tools poses significant challenges to implementing e-Learning, making adequate training and technical support from institutions essential (20). Additionally, managing resistance to new methods is necessary (21). Teachers often struggle to adapt their teaching for online formats, needing to foster productive discussions and maintain effective class management (20). This study highlighted that UMSs had difficulty following lessons due to overlapping conversations, despite teachers' attempts to engage them. To prevent online sessions from becoming chaotic or one-sided, teachers must develop new skills. The involvement of administrative staff and dependable technical support are also vital for a successful transition to e-Learning (21).

Student parameters

UMSs showed a strong preference for "face-to-face" learning, with 64.3% stating that e-Learning could not replace teacher presence, 69.1% believing it could not substitute clinical practice, and 63.4% lamenting the lack of in-person sessions (p < 0.0001 for all responses, Table 2). This aligns with literature suggesting that students often compare their current challenging and uncertain situation to the pre-COVID-19 period, which biases

perceptions against e-Learning (23). The "face-to-face" method is associated with a time free from crisis, whereas e-Learning is linked to pandemic-related disruptions (23). However, this perspective overlooks the successful integration of e-Learning through hybrid models (23).

The negative perception of e-Learning stems from multiple factors, including the abrupt transition and logistical challenges. Communication gaps—such as inadequate long-term planning by the Ministry, slow response from teaching staff, and delays in addressing UMSs' questions—amplified the demand for "face-to-face" learning (23). Videoconferences were deemed demotivating by 64% due to technical issues but were still preferred over pre-recorded videos for the chance to interact with teachers (23). A key limitation highlighted in the literature is the lack of continuous teacher-student interactivity, with 59% of UMSs concerned about insufficient real-time clarification of concepts. Large group interactions during videoconferences were challenging for 46% and 44% of students, respectively. Although some teachers provided discussion spaces and email support, these sporadic efforts (15%, Table 1) and the absence of a dedicated digital space contributed to 47% of students feeling "abandoned" and "isolated" (19). The success of e-Learning relies on addressing 'transactional distance' a concept encompassing not just physical distance but the socio-psychological context and the quality of teacher-student interaction (24).

The analysis showed that 45.7% of UMSs usually did not participate in 'face-to-face' sessions, with 44.7% citing fear of public speaking as a reason. However, 84.2% stated they would participate more if the teacher was perceived as 'nice'. Student withdrawal is common, with fluctuating levels of engagement, similar to findings in 85% of U.S. students (25). Recognizing this behavior is important for ensuring the credibility of the analysis.

Since 2000, generations Y and Z have demanded interactive and appealing learning platforms (23). Despite Moodle being the leading global open-access educational platform since 2002, it faces challenges in satisfying users due to uninteresting design, slow downloads, and limited interactivity (26). Enhancing Moodle can involve features like immediate feedback for quizzes and using interactive applications such as Quizizz or Poll Everywhere for synchronous learning (27). Discussion forums with prompt feedback can also aid communication (27). Integrating social media platforms like Facebook, Messenger, and Twitter into medical education offers immediate interaction, content sharing, and transparency, benefiting from users' familiarity and low implementation costs (28). Twitter, for example, is widely used by surgeons for communication (29). Adopting these tools enhances student engagement and prepares them for the globally connected professional world (30).

This study highlights the controversial use of unconventional information sources with UMSs reporting that 82.7% use Wikipedia, a behavior more common than in Germany (74%) (32) and the UK (63%) (31). Despite the availability of academic resources from FMSo, students continue to rely on Wikipedia, citing easier access

and time constraints (Appendix 2, Section "Students", subsection "Role of other information sources"). However, Wikipedia's nature as an editable, free encyclopedia makes it an unreliable source. To address this, institutions should raise awareness among both teachers and students about the risks to learning quality. A potential solution could be encouraging teachers to interact with students through social networking platforms, creating official learning groups to ensure content quality and reliability.

Environmental parameters

The COVID-19 pandemic has caused widespread psychological distress, particularly among vulnerable groups such as students (33). A significant proportion of UMSs (24.9%) experienced anxiety due to uncertainty about their education and future employment (33). Factors such as fear for personal safety, lack of information about the virus, financial strain, and social isolation contributed to mental health challenges (33). Many students also reported post-traumatic stress and depression, with one-third affected by these conditions (34). Sleep disorders, impaired work performance, emotional instability, and aggression were commonly observed, and stigmatization of certain social groups emerged (34). Women were more emotionally impacted, though they demonstrated better long-term adaptation (35).

UMSs expressed concerns about the future of their training and the credibility of their diplomas, particularly as the pandemic disrupted clinical practice and reduced training quality. Despite prior hybrid learning experience, even prestigious universities faced difficulties fully adapting curricula to e-Learning (23). This has sparked a debate about the adequacy of medical education during the pandemic, with questions about whether future doctors can be granted diplomas with incomplete training (36). Paradoxically, while students acknowledged the negative impact on education quality most opposed remedial programs and favored continuing e-Learning to meet predefined graduation timelines (36).

Comparative studies in the literature

Taking into consideration the context of containment during the COVID-19 pandemic, a comparative study of similar research conducted in developing countries (1,13-15), and the Arab world (16), reported disparate results (Tables 1S and 2S in Appendix 3). Student satisfaction and secondarily the acceptability of the implementation of e-Learning on a larger scale proved to be multifactorial, encompassing economic, sociological, and even geopolitical factors (Tables 1S and 2S in Appendix 3).

The study by Puljak et al. (15) found the highest student satisfaction in e-Learning when expectations were fully met, due to the institution's strong strategy. Success relied on solid logistics, prepared instructors, and dynamic teacher-student interaction, including responsive measures and personalized support during the health crisis (15). However, failures in crisis communication led

to student rejection of e-Learning and heightened anxiety, affecting training quality and credibility. Comparative studies showed that engagement in activities and Moodle discussions depended on how effective students perceived e-Learning as a communication tool (Table 2S in Appendix 3). Tunisian studies confirmed these findings, highlighting severe psychological effects on young medical trainees and the importance of social presence for satisfaction and performance. Unlike the safety-focused behavior in Puljak et al.'s findings (15), Tunisian UMSs, like their British counterparts, volunteered for frontline anti-COVID-19 efforts (37), raising questions about e-Learning's influence on young doctors' decisions.

Study limitations

This study faced four main limitations. First, the questionnaire's validity and reliability were not evaluated beforehand, mainly due to the exceptional and urgent context of its creation and use (38). Additionally, its length (89 items) may have limited participant responses. The second limitation involved the response rate and the high number of "undecided replies" among UMSs, a trend noted in the literature reflecting varying student opinions on the subject (23, 33), from full agreement to minimal participation, particularly as participation was voluntary and anonymous. The third limitation was the predominance of female participants, which could have introduced bias (39). Lastly, some vague expressions, like "the majority of teachers" were used. Since perceptions are influenced by personal experiences (39), "general impressions" were collected, and an "open answers" section was included to let UMSs share their thoughts freely.

Conclusion

The study highlights the profound impact of the sudden shift to e-Learning during the COVID-19 pandemic on North-African UMSs, especially in Tunisia, where medical education faced significant challenges. Limited research on this transition reveals the importance of state-supported policies due to high investment costs and emphasizes that effective logistical preparation, including equipment and trained staff, is vital for success. To address students' sense of isolation from the lack of in-person learning, university teachers should enhance their accessibility and engagement. Additionally, institutions need to master crisis communication to manage the psychological impact of such disruptions. Unlike Western e-Learning models reliant on robust internet and resources, Tunisia's experience showed the crucial role of face-to-face interactions and personalized communication, underscoring the need for globally inclusive perspectives in medical education.

Declaration. In preparing this paper, the authors used ChatGPT model 3.5, to revise some passages of the manuscript, to double-check for any grammar mistakes or improve academic English only. After using this tool, the authors have reviewed and edited the content as necessary and take full responsibility for the content of the publication (40-41).

Supporting information

Appendix 1. French (part A) and English (part B) questionnaires. Link: Ben Saad, H. (2024). Questionnaire used in the study entitled: Perceptions of e-learning among Tunisian medical students during the COVID-19 pandemic: Strategies for effective implementation in medical education. Zenodo. https://doi.org/10.5281/zenodo.14182516

Appendix 2. French (part A) and English (art B) version of the main ideas (grouped by themes) to the open responses to the questinnaire. Link: Ben Saad, H. (2024). French (part A) and English (part B) version of the main ideas (grouped by themes) to the open responses to the questionnaire used in the study entitled: Perceptions of e-learning among Tunisian medical students during the COVID-19 pandemic: Strategies for effective implementation in medical education. Zenodo. https://doi.org/10.5281/zenodo.14182597

Appendix 3. Tables 1S and 2S of the study entitled: Perceptions of e-learning among Tunisian medical students during the COVID-19 pandemic: Strategies for effective implementation in medical education. Link: Ben Saad, H. (2024). Tables 1S and 2S of the study entitled: Perceptions of e-learning among Tunisian medical students during the COVID-19 pandemic: Strategies for effective implementation in medical education. Zenodo. https://doi.org/10.5281/zenodo.14182661

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