

Improving online and blended Learning with Educational Data Analytics

# Gap analysis between the existing and new requirements for online/blended learning teaching materials at each PU

## ILEDA Project Result no.2.1

Project No. 2021-1-BG01-KA220-HED-000031121



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Project ref. number	2021-1-BG01-KA220-HED-000031121
Project title	ILEDA - Improving online and blended learning with educational data analytics
Document title	Act 2.1 - Gap analysis between the existing and new requirements for online/blended learning teaching materials at each PU
Document Type	Project Result
Partner responsible	UEF, Finland

## Table of Content

1	Sec	tion 15
1	Introd	uction5
2	Stu	dents6
	Which	of the methods engage you personally to learn digitally?6
	2.1	Which of the digital collaborations enables you to work on a specific task at ease?7
	2.2	Which of the digital approaches motivates you to learn?
	2.3	Which of the following devices do you use for your online learning?9
	2.4	What is your most preferred method for clearing doubts in online learning?10
	2.5	At home/place of residence, how many responsibilities do you have?
	2.6	Which of the following statements is true of online learning off-campus?
3	Lec	turers
	3.1 lockdo	Which of the following best describes your university circumstances during the COVID-19 owns (think of the period over the past 2 years)
	3.2	Which of the options below best describes teaching circumstances in 2021?14
	3.3	How did you provide remote instruction?15
	3.4	Did you incorporate online-learning into your instruction prior to COVID-19?16
	3.5 into tl	Did your university have a program encouraging teachers to incorporate online learning neir instruction prior to COVID-19?
	3.6 in any	Please indicate to the best of your knowledge if any of your students currently participate of the following arrangements
	3.7	Do you use any of the following techniques for remote learning?
	3.8	How do you build and sustain personal relationships with your students?
	3.9 since	How has the proportion of your teaching time spent on preparation and planning changed COVID-19 pandemic started?21
	3.10 during	Which of the following is the source of the curriculum materials you use in your teaching g COVID-19?
	3.11	Do you use online platforms during COVID-19 for any of the following purposes?23
	3.12 neede	How comfortable/confident do you feel in your ability to use any online tools that are ed for your current approach to instruction?
	3.13 releva	Has your university given you professional development on instructional strategies int to your COVID teaching arrangement?25
	3.14 contir	Are there new resources or practices you've discovered due to COVID-19 that you plan to nue using post-pandemic?
4	Adr	ninistrative staff27

4.1 Which of the following curriculum materials do you expect teachers to use?......27

4.2 Have you adopted online platforms during COVID-19 for any of the following purposes?28

4.3	Please indicate which the following factors influenced your university/faculty curr	rent
offeri	ings	29
4.4	What aspects of your blended or virtual programs do you feel have gone especially w	/ell?
What	t aspects have gone poorly? What would you have done differently?	30
Section	2	31

This report presents in Section 1 a study, aiming to assess the needs of each institution to implement online/blended courses conducted through a set of surveys, as well as the interviews with the administration (institutional leaders) of each university (Annex 1 to 4). Section 2 includes two papers which represent the joined efforts of partner universities beyond the outlined in the project application form to contribute to the studies on the impact of the pandemic on education: one paper, multimethod synthesis of Covid-19 education research and the other, a multi-stakeholder perspective on the gap between existing realities and new requirements for online and blended learning.

### 1 Section 1

### 1 Introduction

The abrupt emergence of COVID-19 has left the whole world in disbelief of the unprecedented situation. A rapid escalation, an unexpected turn of events, has raised questions about our past and current understanding of learning, learning and learning environments. Are we in a situation where all our knowledge still applies or do we have to update our knowledge, and therefore, how we organize learning and teaching? This study aims at answering such a question and explores the perspectives of the main stakeholders: students, lecturers and administrators.

In order to identify sustainable models of online learning, online surveys were created using Google Forms, including multiple-choice questions (with single or multiple answers), Likert scale questions, rating scale questions and open-ended questions. The surveys were distributed among the three types of stakeholders from different scientific fields: students, lecturers and administrative staff from the four partnering European HEIs that participate in the ILEDA project. The survey forms are accessible online. The surveys addressed the following issues:

- What worked during the lockdowns in online teaching?
- What did not work and should be improved?
- What pedagogical approach and methodology were used in class, and what online best practices were used?
- Are there any internal regulations at each university to be followed when implementing new methodologies, so that introduction of such methodologies can be systematic and sustainable?

The questions were based on previous surveys which also aimed to identify instructional practices during the pandemic and assess the effectiveness of online teaching-learning methods for university students. All the participating institutions held predominantly remote instructions during COVID-19, while most of them were partially open. During the period of collecting responses, most of the institutions (3 out of 4) were offering face-to-face classes.

Given the exploratory nature of the study, responses from all institutions were combined – since individual response sample sizes were small – and pre-processed to remove any inconsistencies. The results were analyzed using descriptive statistics (frequencies, proportions, and percentages) with the R statistical software. Below we present the results of the survey. The participants were 112 students, 77 lecturers and 117 members of the administrative staff.

## 2 Students

### Which of the methods engage you personally to learn digitally?

The type of digital learning preferred by students has not seen a consensus among the 112 respondents, where 53 (47.32%) mentioned that blended learning was their preferred method of learning, collaborative learning was selected by 52 students (46.43%), and 62 (55.36%) chose problem-based learning.

	Metropolitan	Sofia	UEF	ULe	Overall
Blended learning	27 (42.86%)	8 (57.14%)	11 (44%)	7 (70%)	53 (47.32%)
Collaborative learning	21 (33.33%)	9 (64.29%)	15 (60%)	7 (70%)	52 (46.43%)
Problem-based learning	34 (53.97%)	6 (42.86%)	18 (72%)	4 (40%)	62 (55.36%)
Problem-based learning					
Collaborative learning					
conaboracive icarining					
Blended learning					
0%	25%	50%		75%	100%
0,0		Percentag	je		20070

# 2.1 Which of the digital collaborations enables you to work on a specific task at ease?

A clear preference for practicing problem-based learning using digital tools (e.g., computers) was seen in a majority of students (84, 75%). Individual work was chosen by only 3 students (2.68%), compared to 69 (61.61%) who chose small group work, 63 (56.25%) chose pairs, and 13 (11.61%) chose large groups.

	Metropolitan	Sofia	UEF	ULe	Overall
Individual	2 (3.17%)	0 (0%)	1 (4%)	0 (0%)	3 (2.68%)
Large group	8 (12.7%)	1 (7.14%)	3 (12%)	1 (10%)	13 (11.61%)
Small group	38 (60.32%)	6 (42.86%)	18 (72%)	7 (70%)	69 (61.61%)
Work in pairs	31 (49.21%)	12 (85.71%)	15 (60%)	5 (50%)	63 (56.25%)



### 2.2 Which of the digital approaches motivates you to learn?

When it comes to the type of materials, students stated their preference for videos (80, 71.43%), simulations (61, 54.46%) and animations (53, 47.32%), as the most motivating digital approaches. Presentation (PowerPoint) was chosen by fewer students (42, 37.5%) and so was the whiteboard and pen (25, 22.32%). The ability to get instant feedback or answers by teachers has also been chosen by a considerable number of students (61, 54.46%).

	Metropolitan	Sofia	UEF	ULe	Overall
Animations	28 (44.44%)	8 (57.14%)	12 (48%)	5 (50%)	53 (47.32%)
Assessments	23 (36.51%)	3 (21.43%)	10 (40%)	2 (20%)	38 (33.93%)
Assignment	21 (33.33%)	7 (50%)	16 (64%)	2 (20%)	46 (41.07%)
Digital pen and slate	8 (12.7%)	3 (21.43%)	8 (32%)	0 (0%)	19 (16.96%)
Instant feedback	38 (60.32%)	8 (57.14%)	10 (40%)	5 (50%)	61 (54.46%)
Powerpoint presentation	20 (31.75%)	4 (28.57%)	15 (60%)	3 (30%)	42 (37.5%)
Simulations	29 (46.03%)	11 (78.57%)	16 (64%)	5 (50%)	61 (54.46%)
Videos	40 (63.49%)	11 (78.57%)	20 (80%)	9 (90%)	80 (71.43%)
Whiteboard and pen	10 (15.87%)	5 (35.71%)	8 (32%)	2 (20%)	25 (22.32%)



# 2.3 Which of the following devices do you use for your online learning?

Almost all the students (111, 99.11%) use computers to learn online, while smartphones came as a distant second (49, 43.75%) and few use tablets (15, 13.39%).

	Metropolitan	Sofia	UEF	ULe	Overall
A laptop/desktop computer	62 (98.41%)	14 (100%)	25 (100%)	10 (100%)	111 (99.11%)
A smartphone	26 (41.27%)	9 (64.29%)	7 (28%)	7 (70%)	49 (43.75%)
A tablet	8 (12.7%)	1 (7.14%)	2 (8%)	4 (40%)	15 (13.39%)
Other devices	1 (1.59%)	0 (0%)	2 (8%)	0 (0%)	3 (2.68%)
Other devices					
A tablet					
A smartphone					
A laptop/desktop computer					
0%	0% 25%		<sup>0%</sup> ntage	75%	100%

# 2.4 What is your most preferred method for clearing doubts in online learning?

Using computers to search for help was the chosen way by students to clear doubts (82, 73.21%), search online course material (66, 58.93%), or seek help from the instructor online (60, 53.57%).

	Metropolitan	Sofia	UEF	ULe	Overall
Ask the professor during/after an online lecture	33 (52.38%)	7 (50%)	14 (56%)	6 (60%)	60 (53.57%)
Communicate with my classmates in person and ask for help	28 (44.44%)	10 (71.43%)	11 (44%)	5 (50%)	54 (48.21%)
Go through online material providing an additional explanation	36 (57.14%)	11 (78.57%)	15 (60%)	4 (40%)	66 (58.93%)
Post the query in a discussion forum of your class and get help from your peers	11 (17.46%)	1 (7.14%)	10 (40%)	1 (10%)	23 (20.54%)
Search on the internet for more information	47 (74.6%)	12 (85.71%)	16 (64%)	7 (70%)	82 (73.21%)



## 2.5 At home/place of residence, how many responsibilities do you have?

Most students said they have at least a moderate amount of time to work online (82, 73.21%), while a small percentage said that they have limited time for online learning (11, 9.82%) or too many responsibilities that may make their time for online work limited (11, 9.82%).

	Metropolitan	Sofia	UEF	ULe	Overall
I don't have any time left for online learning	8 (12.7%)	1 (7.14%)	1 (4%)	1 (10%)	11 (9.82%)
I don't have many responsibilities	10 (15.87%)	0 (0%)	7 (28%)	3 (30%)	20 (17.86%)
I have a moderate amount of responsibilities but I have sufficient time for online learning	45 (71.43%)	13 (92.86%)	18 (72%)	6 (60%)	82 (73.21%)
I have many responsibilities	8 (12.7%)	1 (7.14%)	1 (4%)	1 (10%)	11 (9.82%)



### 2.6 Which of the following statements is true of online learning offcampus?

Hindrance to online learning by peers, roommates or family was seen as an obstacle by very few students (5, 4.46%), while less than half said they have occasional disturbances (50, 44.64%), and more than half said that they had no disturbance at all (61, 54.46%).

	Metropolitan	Sofia	UEF	ULe	Overall
My friend/family member/roommate/neighbour constantly disturb me	3 (4.76%)	0 (0%)	2 (8%)	0 (0%)	5 (4.46%)
My friend/family member/roommate/neighbour occasionally disturb me	23 (36.51%)	9 (64.29%)	10 (40%)	8 (80%)	50 (44.64%)
No one disturbs me during my online learning	37 (58.73%)	6 (42.86%)	16 (64%)	2 (20%)	61 (54.46%)



### 3 Lecturers

Other interesting stakeholders to consider are lecturers, as they had to adapt their teaching in a short period and in many cases with lack of enough experience with online learning. The involved lecturers from the four universities were 77.

# 3.1 Which of the following best describes your university circumstances during the COVID-19 lockdowns (think of the period over the past 2 years)

For teachers, the first issue to explore is the context, that is, circumstances during lock-down and after it. From the surveyed lecturers, it is possible to see that most of the institutions were closed (30, 38.96%) or only partially open and with limited access (40, 51.95%).



# 3.2 Which of the options below best describes teaching circumstances in 2021?

In this situation, 57 (74.03%) lecturers stated that they taught remotely, while few teach in a hybrid way and only one teacher taught face-to-face.

	Metropolitan	Sofia	UEF	ULe	Overall
I taught all my students remotely.	35 (92.11%)	17 (77.27%)	3 (42.86%)	2 (20%)	57 (74.03%)
I taught all of my students in a physical classroom.	0 (0%)	0 (0%)	0 (0%)	1 (10%)	1 (1.3%)
I taught all of my students via a mix of classroom and remote instruction.	3 (7.89%)	5 (22.73%)	3 (42.86%)	3 (30%)	14 (18.18%)
I taught some students in-person and other students remotely.	0 (0%)	0 (0%)	1 (14.29%)	4 (40%)	5 (6.49%)



### 3.3 How did you provide remote instruction?

Most of the respondents (55, 71.43%) carried out their classes synchronously through daily class sessions over video calls for an amount of time similar to a regular school day, and just 18 (23.38%) mixed synchronous and asynchronous activities.

	Metropolitan	Sofia	UEF	ULe	Overall
Students received a mix of synchronous and asynchronous instruction each day.	2 (5.26%)	11 (50%)	2 (28.57%)	3 (30%)	18 (23.38%)
Students received most of their instruction asynchronously by completing learning activities independently	2 (5.26%)	0 (0%)	2 (28.57%)	0 (0%)	4 (5.19%)
Students received most of their instruction synchronously through daily class sessions over video calls for an amount of time similar to a regular school day.	34 (89.47%)	11 (50%)	3 (42.86%)	7 (70%)	55 (71.43%)



# 3.4 Did you incorporate online-learning into your instruction prior to COVID-19?

The lecturers used online learning before COVID-19 to a large extent (43, 55.84%) and to a small extent (19, 24.68%).

	Metropolitan	Sofia	UEF	ULe	Overall
A little	12 (31.58%)	3 (13.64%)	2 (28.57%)	2 (20%)	19 (24.68%)
A lot	20 (52.63%)	15 (68.18%)	4 (57.14%)	4 (40%)	43 (55.84%)
Does not apply	6 (15.79%)	0 (0%)	1 (14.29%)	1 (10%)	8 (10.39%)
Not at all	0 (0%)	4 (18.18%)	0 (0%)	3 (30%)	7 (9.09%)



### 3.5 Did your university have a program encouraging teachers to incorporate online learning into their instruction prior to COVID-19?

Some 44 (57.14%) respondents reported that their institutions promoted incorporating online teaching through a formal program even prior to COVID-19.

	Metropolitan	Sofia	UEF	ULe	Overall
Don't know	3 (7.89%)	0 (0%)	2 (28.57%)	1 (10%)	6 (7.79%)
Formal program	29 (76.32%)	11 (50%)	1 (14.29%)	3 (30%)	44 (57.14%)
Informal program	2 (5.26%)	8 (36.36%)	3 (42.86%)	3 (30%)	16 (20.78%)
No program	3 (7.89%)	3 (13.64%)	1 (14.29%)	3 (30%)	10 (12.99%)



# 3.6 Please indicate to the best of your knowledge if any of your students currently participate in any of the following arrangements

In addition, lecturers point out that students participate in online learning activities such as the use of tutoring services arranged by the university (35, 45.45%), learning hubs (19, 24.68%) and virtual interaction with industry professionals (18, 23.38%).

	Metropolitan	Sofia	UEF	ULe	Overall
l don't know.	3 (7.89%)	1 (4.55%)	0 (0%)	0 (0%)	4 (5.19%)
I personaly inform students about online conferences and public online lectures that can be useful for further linking and advance	1 (2.63%)	0 (0%)	0 (0%)	0 (0%)	1 (1.3%)
Learning hubs in which students can get in- person support for remote learning	10 (26.32%)	4 (18.18%)	1 (14.29%)	4 (40%)	19 (24.68%)
Students study asynchronously through an e-learning platform	1 (2.63%)	0 (0%)	0 (0%)	0 (0%)	1 (1.3%)
Tutoring services arranged by your university to support remote learning	20 (52.63%)	7 (31.82%)	4 (57.14%)	4 (40%)	35 (45.45%)
Virtual interactions with a mentor or industry experts (i.e. non-university employees) arranged by your university	11 (28.95%)	5 (22.73%)	0 (0%)	2 (20%)	18 (23.38%)



### 3.7 Do you use any of the following techniques for remote learning?

When we talk about teaching, we can discuss the employed techniques, the ways in which the lecturers interact with students, and the development of teaching content. Regarding the used techniques for remote learning, the most common were videoconference systems for presentations (66, 85.71%), online pooling or quizzes (45, 58.44%), project based learning approaches (43, 55.84%) or small groups synchronous activities (36, 46.75%).

	Metropolitan	Sofia	UEF	ULe	Overall
Individualized learning progressions and pacing	11 (28.95%)	6 (27.27%)	3 (42.86%)	2 (20%)	22 (28.57%)
Mastery-based learning	6 (15.79%)	0 (0%)	0 (0%)	3 (30%)	9 (11.69%)
Online lab activities	5 (13.16%)	7 (31.82%)	0 (0%)	8 (80%)	20 (25.97%)
Online polling or quizzes	20 (52.63%)	14 (63.64%)	5 (71.43%)	6 (60%)	45 (58.44%)
Other	1 (2.63%)	0 (0%)	0 (0%)	0 (0%)	1 (1.3%)
Project-based learning	16 (42.11%)	16 (72.73%)	5 (71.43%)	6 (60%)	43 (55.84%)
Small group asynchronous activities	7 (18.42%)	11 (50%)	4 (57.14%)	3 (30%)	25 (32.47%)
Small group synchronous activities online (e.g. Zoom breakout rooms)	17 (44.74%)	10 (45.45%)	6 (85.71%)	3 (30%)	36 (46.75%)
Student speeches or presentations online (e.g. over Zoom)	34 (89.47%)	19 (86.36%)	5 (71.43%)	8 (80%)	66 (85.71%)
Tutoring or peer-to-peer learning program	5 (13.16%)	6 (27.27%)	1 (14.29%)	4 (40%)	16 (20.78%)



# 3.8 How do you build and sustain personal relationships with your students?

If we consider the student-lecturer interaction, the preferred methods by the lecturers were email (65, 84.42%) and whole class video calls (69, 89.61%).

	Metropolitan	Sofia	UEF	ULe	Overall
Email	33 (86.84%)	19 (86.36%)	7 (100%)	6 (60%)	65 (84.42%)
Messaging	7 (18.42%)	16 (72.73%)	3 (42.86%)	5 (50%)	31 (40.26%)
One-on-one video calls	25 (65.79%)	3 (13.64%)	4 (57.14%)	4 (40%)	36 (46.75%)
Small group video calls	20 (52.63%)	6 (27.27%)	2 (28.57%)	4 (40%)	32 (41.56%)
Social media	8 (21.05%)	6 (27.27%)	2 (28.57%)	0 (0%)	16 (20.78%)
Telephone	3 (7.89%)	2 (9.09%)	0 (0%)	0 (0%)	5 (6.49%)
Using forums and message system in Moodle	0 (0%)	1 (4.55%)	0 (0%)	0 (0%)	1 (1.3%)
Whole-class video calls	36 (94.74%)	20 (90.91%)	5 (71.43%)	8 (80%)	69 (89.61%)



# 3.9 How has the proportion of your teaching time spent on preparation and planning changed since COVID-19 pandemic started?

Migration to remote learning influenced a change in the time needed for lecturers to prepare classes and according to 51 (66.23%) respondents this time increased.

	Metropolitan	Sofia	UEF	ULe	Overall
About the same	14 (36.84%)	4 (18.18%)	3 (42.86%)	0 (0%)	21 (27.27%)
Does not apply	0 (0%)	0 (0%)	1 (14.29%)	0 (0%)	1 (1.3%)
Don't know	1 (2.63%)	0 (0%)	0 (0%)	0 (0%)	1 (1.3%)
Less time on preparation and planning	2 (5.26%)	0 (0%)	0 (0%)	1 (10%)	3 (3.9%)
More time on preparation and planning	21 (55.26%)	18 (81.82%)	3 (42.86%)	9 (90%)	51 (66.23%)



# 3.10 Which of the following is the source of the curriculum materials you use in your teaching during COVID-19?

When considering the resources used, 70 lecturers (90.91%) used materials they developed themselves, 33 (42.86%) used materials someone else developed in their institution, while 47 (61.04%) respondents stated they used resources collated from other online sources.

	Metropolitan	Sofia	UEF	ULe	Overall
Commercial curriculum designed for classroom- based instruction	7 (18.42%)	1 (4.55%)	0 (0%)	0 (0%)	8 (10.39%)
Commercial curriculum designed for remote instruction	6 (15.79%)	2 (9.09%)	0 (0%)	0 (0%)	8 (10.39%)
Materials developed by others in my university	20 (52.63%)	9 (40.91%)	3 (42.86%)	1 (10%)	33 (42.86%)
Materials I develop	31 (81.58%)	22 (100%)	7 (100%)	10 (100%)	70 (90.91%)
Open-source curriculum	0 (0%)	5 (22.73%)	1 (14.29%)	3 (30%)	9 (11.69%)
Various resources collated from online sources	19 (50%)	17 (77.27%)	7 (100%)	4 (40%)	47 (61.04%)



# 3.11 Do you use online platforms during COVID-19 for any of the following purposes?

It is also interesting to attend to how lecturers use online platforms during COVID-19. Some 70 (90.91%) lecturers use them for live instruction over video; 44 (57.14%) use it for creating online lessons and 28 (36.36%) use it for managing dif-ferent kinds of activities and tests.

	Metropolitan	Sofia	UEF	ULe	Overall
Creating online lessons	11 (28.95%)	20 (90.91%)	6 (85.71%)	7 (70%)	44 (57.14%)
I do not use online platforms for any of the above purposes	1 (2.63%)	0 (0%)	0 (0%)	0 (0%)	1 (1.3%)
Live instruction over video	37 (97.37%)	17 (77.27%)	7 (100%)	9 (90%)	70 (90.91%)
Managing online assignments/tests	4 (10.53%)	12 (54.55%)	4 (57.14%)	8 (80%)	28 (36.36%)
Other	3 (7.89%)	3 (13.64%)	2 (28.57%)	0 (0%)	8 (10.39%)



# 3.12 How comfortable/confident do you feel in your ability to use any online tools that are needed for your current approach to instruction?

Regarding teachers' perception of their own online teaching skills, they feel quite comfortable and confident with their ability using online tools for instruction.

Institution	Mean	Median	SD
Metropolitan	4.680000	5.0	0.5300000
Sofia	4.500000	5.0	0.6700000
UEF	4.570000	5.0	0.5300000
ULe	4.400000	4.5	0.7000000
Overall	4.584416	5.0	0.5927334

# 3.13 Has your university given you professional development on instructional strategies relevant to your COVID teaching arrangement?

According to 60 (77.92%) respondents the institutions provided lecturers with professional development on instructional strategies relevant to their COVID-19 teaching arrangement. In fact, they felt well abled to teach the students properly.

	Metropolitan	Sofia	UEF	ULe	Overall
Does not apply	0 (0%)	1 (4.55%)	0 (0%)	0 (0%)	1 (1.3%)
Don't know	1 (2.63%)	0 (0%)	0 (0%)	0 (0%)	1 (1.3%)
No	6 (15.79%)	2 (9.09%)	2 (28.57%)	5 (50%)	15 (19.48%)
Yes	31 (81.58%)	19 (86.36%)	5 (71.43%)	5 (50%)	60 (77.92%)



# 3.14 Are there new resources or practices you've discovered due to COVID-19 that you plan to continue using post-pandemic?

Moreover, lecturers have learnt from the pandemic situation and 51 (66.23%) re-spondents have discovered new practices which they aim to continue applying.



### 4 Administrative staff

The administrative staff (administrators) perspective complements the students' and lecturers' perception, as the HEI administration supports the learning and teaching process and complies with the national and university procedures and requirements during the pandemic. Therefore, beyond collecting their opinion of the instructional model and approach, we have gained some insights on the learning and teaching methods and activities. A total of 17 administrators responded to the survey.

## 4.1 Which of the following curriculum materials do you expect teachers to use?

The administrators' opinion on the types of curriculum materials, which teachers will use after teaching during the pandemic COVID-19, fully overlaps with the perception of the teachers. Some 15 administrators (88.24%) have stated that most of the teaching materials were developed by the teachers in their own institution, while 13 (76.47%) stated that instructors used various resources collated from online resources. Equal share (10, 58.82%) considered that open-source curriculum and materials developed by the university will be used in teaching. Very few respondents (3, 17.65%) expect that teachers will use commercial curriculum designed for classroom-based instruction and commercial curriculum designed for remote instruction.

	Metropolitan	Sofia	UEF	ULe	Overall
Commercial curriculum designed for classroom- based instruction	0 (0%)	3 (60%)	0 (0%)	0 (0%)	3 (17.65%)
Commercial curriculum designed for remote instruction	1 (16.67%)	2 (40%)	0 (0%)	0 (0%)	3 (17.65%)
Materials developed by the university	2 (33.33%)	4 (80%)	1 (100%)	3 (60%)	10 (58.82%)
Materials teachers develop	5 (83.33%)	4 (80%)	1 (100%)	5 (100%)	15 (88.24%)
Open-source curriculum	3 (50%)	3 (60%)	1 (100%)	3 (60%)	10 (58.82%)
Platform or repository with learning materials	0 (0%)	1 (20%)	0 (0%)	0 (0%)	1 (5.88%)
Various resources collated from online sources	5 (83.33%)	3 (60%)	1 (100%)	4 (80%)	13 (76.47%)



Creating online lessons (e.g. Moodle and Blackboard)

# 4.2 Have you adopted online platforms during COVID-19 for any of the following purposes?

All of the institutions used learning management systems (e.g. Moodle) for creating online lessons and provided live instructions using video conferencing tools such as Zoom, Google Meet, BigBlueButton, etc.

	Metropolitan	Sofia	UEF	ULe	Overall
Creating online lessons (e.g. Moodle and Blackboard)	3 (50%)	4 (80%)	1 (100%)	2 (40%)	10 (58.82%)
Live instruction over video (e.g. Zoom and Google Meet)	4 (66.67%)	4 (80%)	1 (100%)	5 (100%)	14 (82.35%)
Managing online assignments (e.g. Google Classroom and Canvas)	2 (33.33%)	5 (100%)	1 (100%)	2 (40%)	10 (58.82%)
Managing online assignments (e.g. Google Classroom and Canvas)					
Live instruction over video (e.g. Zoom and Google Meet)					

25%

50%

Percentage

75%

100%

0%



# 4.3 Please indicate which the following factors influenced your university/faculty current offerings

In relation to factors influencing university's current offerings, among all, a set of factors are related to teaching and another one to technological support to learning and teaching. Administrators outlined teacher training (8, 47.06%) as a very im-portant issue, and the need to set up training programs quickly was highlighted by 10 respondents (58.82%). Technological support to teaching and learning is also af-fecting current offerings as quality of technology and programs available for purchase was seen by 6 respondents (35.29%), which was more crucial in comparison to lim-ited technological infrastructure to support remote education (5, 29.41%), and lack of devices or internet for remote students (2, 11.76%).

	Metropolitan	Sofia	UEF	ULe	Overall
Attendance counting requirements	1 (16.67%)	2 (40%)	0 (0%)	2 (40%)	5 (29.41%)
Concerns about equity	0 (0%)	0 (0%)	1 (100%)	0 (0%)	1 (5.88%)
Concerns about retaining enrollment	1 (16.67%)	0 (0%)	1 (100%)	1 (20%)	3 (17.65%)
Course development and/or purchasing costs	1 (16.67%)	2 (40%)	1 (100%)	3 (60%)	7 (41.18%)
Lack of devices or internet for remote students	0 (0%)	0 (0%)	0 (0%)	2 (40%)	2 (11.76%)
Limited technological infrastructure to support remote education	0 (0%)	2 (40%)	1 (100%)	2 (40%)	5 (29.41%)
Per-student funding requirements	2 (33.33%)	0 (0%)	0 (0%)	1 (20%)	3 (17.65%)
Quality of technology and programs available for purchase	1 (16.67%)	4 (80%)	0 (0%)	1 (20%)	6 (35.29%)
Required instructional minutes	0 (0%)	1 (20%)	0 (0%)	1 (20%)	2 (11.76%)
Required teacher training	2 (33.33%)	2 (40%)	1 (100%)	3 (60%)	8 (47.06%)
The need to set programs up quickly	3 (50%)	3 (60%)	1 (100%)	3 (60%)	10 (58.82%)



### 4.4 What aspects of your blended or virtual programs do you feel have gone especially well? What aspects have gone poorly? What would you have done differently?

Some of the comments by the administrative staff in regard to positive aspects in blended and virtual programs were that they have worked quite effectively. According to university administrators, the communication was good and more students were able to at-tend courses online compared to face-to-face mode. They added that teaching theoret-ical materials online went especially well. Negative aspects in blended and virtual programs which administrative staff shared are that the educational process went poorly when it was necessary for teachers to use some physical devices (equipment) for teaching and learning. Also, they shared that IT subjects were challenging to be taught, because students needed to be im-mersed in technology from a distance. Generally, administrative staff considered con-ducting online lab classes was not efficient. Administrators shared that teaching Math online does not encourage students to ask for a re-explanation and clarification in case of omission or misunderstanding of the matter. The following list contains examples of administrators' responses:

- "I think that flexibility and collaborately developed ideas together with university teachers, administrators and students, to support student learning in the challenging times, worked quite well. We had also innovative teachers who were willing to share their ideas for the online and remote teaching, and suggestions for solutions shared. For some teachers, their workload was already so high that it hindered their energy to develop new tehcnology-pedagogical ideas and solutions, so they only turned their on-site course to online teaching without probably careful pedagogical plan. Thus, fos some programs, the teaching might have been not so efficient in supporting student learning in online contexts."
- "Hybrid programmes"
- "We have developed an online learning system which well rounded is received well by the students."
- "The virtual programs have worked quite well, although several control aspects have had to be improved."
- "Adaption must be carried out very quickly"
- "We adapted to the situation, we would have need more time and teaching"
- "It went well the communication, more students were able to attend the courses online. It was poorly when it was necessary to use physical devices for teaching and learning purposes."
- "Training in IT subjects challenged students to immerse themselves in technology
- "In the Teaching of Math / Math subjects, distance learning does not encourage students to request a re-explanation in case of omission / misunderstanding"
- "especially well teaching of the theoretical meterial; poorly doing skills labs; differently - to try to stimulate students to participate actively on online sessions"

## Section 2

## Multi-stakeholder Perspective on the Gap between Existing Realities and New Requirements for Online and Blended Learning: An Exploratory Study

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Online and blended learning are teaching modalities that have become very popular and widespread all over the world. Applying these modalities requires specific knowledge as well as an appropriate technological infrastructure. The COVID-19 pandemic caused an important online migration in most educational institutions. In this regard, existing literature covers issues such as the impact, the challenges, the tools, the problems, etc. What could also be interesting is to understand students', teachers' and administrative staff's perspectives about how blended and online learning were developed and how it is going to be applied in the future. With this in mind, the ILEDA project team has carried out an exploratory study, which takes into account these three collectives in four different European universities. From the study, it is possible to see that the institutions and their lecturers and staff were probably not prepared for the online migration and the possibilities they had were quite different from students' expectations.

Keywords: higher education, e-learning, blended learning, COVID-19 period

#### 1. Introduction

In the last few years, educational institutions had to change to survive in the pandemic landscape, which had several implications. For higher education institutions (HEI), the shift from traditional, face-to-face learning to distance learning has been an opportunity to develop and include flexible learning modalities [1-5].

Two main distance teaching modalities have become prevalent in HEIs during the COVID-19 crisis: full online learning and blended (hybrid) learning. Both modalities require innovative tools to support teaching and learning and to offer flexible learning pathways. These tools include a mix of digital solutions for different pedagogies, approaches and technological platforms [4, 6, 7]. While conducting online and blended learning in higher education has posed many challenges, it has also presented a great opportunity to develop sustainable learning models for the future, which constitute a step towards developing adequate teaching models for the digital era, new effective teaching practices, and an overall supportive learning environment [5, 8].

Something especially critical that HEIs should consider is the existence of new realities derived from COVID-19 and the way in which technology in the field of e-learning evolves. Regarding the new realities derived from COVID-19, it is clear that lecturers, students and administrative staff (administrators) were forced to move to online learning approaches during the pandemic and many of the newly adopted processes will remain over time. This implies an increase in blended and online learning activities and some associated requirements such as tools, methodologies, teacher training, etc. [5, 6, 8].

In addition to this, the way in which e-learning approaches are carried out are not the same as ten years ago. The technological advances, the evolution of the Internet, the possibility to have access to the information at any moment, the opportunity of analyzing the information, to apply Learning Analytics or even Machine Learning techniques may lead to a new landscape for blended and online learning [9-11]. This paper deals with these topics by the implementation of an exploratory study that considers the perspective of students, lecturers and administrative staff of four different European HEIs. The study was carried out in the context of the ILEDA Erasmus+ project [12]. ILEDA project is led by Sofia University St. Kliment Ohridski (Bulgaria) and also involves the Belgrade Metropolitan University (Serbia), the University of León (Spain) and the University of Eastern Finland (Finland). The project aims to solve several problems of higher participation in online and blended courses and to provide support to learning environments that are in use at the participating educational institutions. The support to learning analytics software tool that can be integrated in any learning environment and used to actively monitor students' performances.

The rest of the paper is structured as follows. Section 2 presents the study context, sample and description of methods. Section 3 presents the results of the study according to students' perspective, lecturers' perspective and administrative staff's perspective. Section 4 includes the discussion about the findings and some conclusions.

#### 2. Context, sample and methods

In order to identify sustainable models of online learning, online surveys were created using Google Forms, including multiple-choice questions (with single or multiple answers), Likert scale questions, rating scale questions and open-ended questions. The surveys were distributed among three types of stakeholders from different scientific fields: students, lecturers and administrative staff from the four partnering European HEIs that participate in the ILEDA project. The survey forms are accessible online [13-15]. The surveys addressed the following issues:

- What worked during the lockdowns in online teaching?
- What did not work and should be improved?
- What pedagogical approach and methodology were used in class, and what online best practices were used?
- Are there any internal regulations at each university to be followed when implementing new methodologies, so that introduction of such methodologies can be systematic and sustainable?

The questions were based on previous surveys [16, 17], which also aimed to identify instructional practices during the pandemic and assess the effectiveness of online teaching-learning methods for university students. All the participating institutions held predominantly remote instructions during COVID-19, while most of them were partially open. During the period of collecting responses, most of the institutions (3 out of 4) were offering face-to-face classes.

Given the exploratory nature of the study, responses from all institutions were combined – since individual response sample sizes were small – and pre-processed

to remove any inconsistencies. The results were analyzed using descriptive statistics (frequencies, proportions, and percentages) with the R statistical software.

#### 3. Results

This section presents results from Students' Survey (n=112), Lecturers' Survey (n=77) and Administrative Staffs' Survey (n=17).

#### 3.1. Students

The type of digital learning preferred by students has not seen a consensus among the 112 respondents, where 53 (47.32%) mentioned that blended learning was their preferred method of learning, collaborative learning was selected by 52 students (46.43%), and 62 (55.36%) chose problem-based learning. A clear preference for practicing problem-based learning using digital tools (e.g., computers) was seen in a majority of students (84, 75%). Individual work was chosen by only 3 students (2.68%), compared to 69 (61.61%) who chose small group work, 63 (56.25%) chose pairs, and 13 (11.61%) chose large groups. When it comes to the type of materials, students stated their preference for videos (80, 71.43%), simulations (61, 54.46%) and animations (53, 47.32%), as the most motivating digital approaches. Presentation (PowerPoint) was chosen by fewer students (42, 37.5%) and so was the whiteboard and pen (25, 22.32%). Almost all the students (111, 99.11%) use computers to learn online, while smartphones came as a distant second (49, 43.75%) and few use tablets (15, 13.39%). Using computers to search for help was the chosen way by students to clear doubts (82, 73.21%), search online course material (66, 58.93%), or seek help from the instructor online (60, 53.57%). The ability to get instant feedback or answers by teachers has also been chosen by a considerable number of students (61, 54.46%). Most students said they have at least a moderate amount of time to work online (82, 73.21%), while a small percentage said that they have limited time for online learning (11, 9.82%) or too many responsibilities that may make their time for online work limited (11,9.82%). Hindrance to online learning by peers, roommates or family was seen as an obstacle by very few students (5, 4.46%), while less than half said they have occasional disturbances (50, 44.64%), and more than half said that they had no disturbance at all (61, 54.46%).

#### 3.2. Lecturers

Other interesting stakeholders to consider are lecturers, as they had to adapt their teaching in a short period and in many cases with lack of enough experience with online learning. The involved lecturers from the four universities were 77. For them, the first issue to explore is the context, that is, circumstances during lockdown and after it. From the surveyed lecturers, it is possible to see that most of the institutions were closed (30, 38.96%) or only partially open and with limited access (40, 51.95%). In this situation, 57 (74.03%) lecturers stated that they taught remotely; most of them (55, 71.43%) carried out their classes synchronously through daily class sessions over video calls for an amount of time similar to a regular school day, and just 18 (23.38%) mixed synchronous and asynchronous activities. This could be conditioned by their previous experience with online learning, so the teachers were asked about it. The lecturers used online learning before COVID-19 to a large extent (43, 55.84%) and to a small extent (19, 24.68%). Some 44 (57.14%) respondents reported that their institutions promoted incorporating online teaching through a formal program even prior to COVID-19. In addition, lecturers point out that students participate in online learning activities such as the use of tutoring services arranged by the university (35, 45.45%), learning hubs (19, 24.68%) and virtual interaction with industry professionals (18, 23.38%).

When we talk about teaching, we can discuss the employed techniques, the ways in which the lecturers interact with students, and the development of teaching content. Regarding the used techniques for remote learning, the most common were videoconference systems for presentations (66, 85.71%), online pooling or quizzes (45, 58.44%), project based learning approaches (43, 55.84%) or small groups synchronous activities (36, 46.75%). If we consider the student-lecturer interaction, the preferred methods by the lecturers were email (65, 84.42%) and whole class video calls (69, 89.61%). Migration to remote learning influenced a change in the time needed for lecturers to prepare classes and according to 51 (66.23%) respondents this time increased. When considering the resources used, 70 lecturers (90.91%) used materials they developed themselves, 33 (42.86%) used materials someone else developed in their institution, while 47 (61.04%) respondents stated they used resources collated from other online sources.

It is also interesting to attend to how lecturers use online platforms during COVID-19. Some 70 (90.91%) lecturers use them for live instruction over video; 44 (57.14%) use it for creating online lessons and 28 (36.36%) use it for managing different kinds of activities and tests.

Regarding teachers' perception of their own online teaching skills, they feel quite comfortable and confident with their ability using online tools for instruction. According to 60 (77.92%) respondents the institutions provided lecturers with professional development on instructional strategies relevant to their COVID-19 teaching arrangement. In fact, they felt well abled to teach the students properly. Moreover, lecturers have learnt from the pandemic situation and 51 (66.23%) respondents have discovered new practices which they aim to continue applying.

#### 3.3. Administrative Staff

The administrative staff (administrators) perspective complements the students' and lecturers' perception, as the HEI administration supports the learning and teaching process and complies with the national and university procedures and requirements during the pandemic. Therefore, beyond collecting their opinion of the instructional model and approach, we have gained some insights on the learning and teaching methods and activities. A total of 17 administrators responded to the survey. The administrators' opinion on the types of curriculum materials, which teachers will use after teaching during the pandemic COVID-19, fully overlaps with the perception of the teachers. Some 15 administrators (88.24%) have stated that most of the teaching materials were developed by the teachers in their own institution, while 13 (76.47%) stated that instructors used various resources collated from online resources. Equal share (10, 58.82%) considered that open-source curriculum and materials developed by the university will be used in teaching. Very few respondents (3, 17.65%) expect that teachers will use commercial curriculum designed for classroom-based instruction and commercial curriculum designed for remote instruction. All of the institutions used learning management systems (e.g. Moodle) for creating online lessons and provided live instructions using video conferencing tools such as Zoom, Google Meet, BigBlueButton, etc.

In relation to factors influencing university's current offerings, among all, a set of factors are related to teaching and another one to technological support to learning and teaching. Administrators outlined teacher training (8, 47.06%) as a very important issue, and the need to set up training programs quickly was highlighted by 10 respondents (58.82%). Technological support to teaching and learning is also affecting current offerings as quality of technology and programs available for purchase was seen by 6 respondents (35.29%), which was more crucial in comparison to limited technological infrastructure to support remote education (5, 29.41%), and lack of devices or internet for remote students (2, 11.76%).

One of the questions in the administrative staff surveys was open ended. Some of the comments by the administrative staff in regard to positive aspects in blended and virtual programs were that they have worked quite effectively. According to university administrators, the communication was good and more students were able to attend courses online compared to face-to-face mode. They added that teaching theoretical materials online went especially well.

Negative aspects in blended and virtual programs which administrative staff shared are that the educational process went poorly when it was necessary for teachers to use some physical devices (equipment) for teaching and learning. Also, they shared that IT subjects were challenging to be taught, because students needed to be immersed in technology from a distance. Generally, administrative staff considered conducting online lab classes was not efficient. Administrators shared that teaching Math online does not encourage students to ask for a re-explanation and clarification in case of omission or misunderstanding of the matter.

6

#### 4. Discussion

The abrupt emergence of COVID-19 has left the whole world in disbelief of the unprecedented situation. A rapid escalation, an unexpected turn of events, has raised questions about our past and current understanding of learning, learning and learning environments. Are we in a situation where all our knowledge still applies or do we have to update our knowledge, and therefore, how we organize learning and teaching? [18]. This study aims at answering such a question and explores the perspectives of the main stakeholders: students, lecturers and administrators.

Our first stakeholders were the students who are the main target –or the beneficiaries– of the whole educational process. While collaborative learning is far from easy to implement, students have stated that they think collaboration can help them perform tasks better than working individually. As such, collaborative learning, problem-based learning and working in groups (pairs or small groups) were chosen by the majority of students. Furthermore, students chose media-rich learning materials (videos, animations and simulations) as their preferred sources. While most of the students would search for information on the Internet on their own when they are seeking answers, they appreciate timely feedback from teachers. Interestingly, students have said that online learning is feasible and it has no major hindrance from family, friends or time constraints. In summary, students' preferences for learning methods, materials or feedback are stimulating, yet intensive and challenging to organize during a pandemic time.

Our second stakeholders, the teachers, have expressed their preference for synchronous learning such as video-conferencing and for personally prepared or curated learning resources. Just less than half of the teachers were not essentially trained or practiced online learning before COVID-19. Obviously, the lack of practice has created a challenging situation for teachers and students alike. In fact, all teachers regardless of their previous experience faced time intensive tasks to prepare for online learning. Teachers also said that they delivered their support for students mainly through emails and messaging.

While teachers' and students' points of view were not competing, they were not aligned on major and important points. Students' preferences for blended learning contrasts with teachers' preferences for synchronous learning through video-conferencing. Students' preference for collaborative problem-based learning and project based learning seems to be infeasible given the described methods of teaching, time constraints and level of teachers' training [19].

The opinions of administrators complemented and oftentimes overlapped with teachers regarding the type of learning materials and methods of learning. It was also obvious that administrators emphasized the importance of teachers' training, proper infrastructure, digital tools, and support as facilitators of learning. Nevertheless, administrators were more aware of the challenge of teaching practical subjects (e.g., biology and physics) which require use of physical equipment. Institutions needed to acquire virtual laboratories or simulated solutions; yet their experience and the time to choose were not on their side. However, there are possible virtual solutions that are not always known [20, 21].

#### 5. Conclusions

Overall, the exploration of opinions paints a picture of students who want more active, participatory learning with timely feedback that can be complemented or supported by blended learning. Put another way, students wanted learning that is pre-COVID-19. Teachers and administrators had to survive with what was available at hand from pre-COVID-19 times, which at best helped deliver online synchronous learning, learning resources over learning management system (LMS). However, such resources fell short in providing the active learning, practical experiences or a stimulating experience that students want. This situation probably amounted to the lack of motivation that was reported by students in other studies.

There are of course areas where students and educators meet e.g., preference for active teaching. Nonetheless, the realities showed a disconnect regarding the methods of applications of online learning on the ground. Which begs the need for more conversation between stakeholders, better proactive preparation, staff development and opening continuous dialogue channels with the students.

Future research may use a larger more representative sample, address the contextual diversities, and build on what we have learnt in this explorative study.

#### Limitation

The fact that the sample size was small and diverse (from multiple institutions) makes our study results exploratory, and therefore, caution should be exercised before interpreting the results as generalizable or representative of the respective institutions or stakeholders. A future larger study with representative samples will be performed to enable a more accurate view of such a question.

#### Acknowledgements

Research presented in this paper is supported by the project "Improving online and blended learning with educational data analytics" ILEDA - 2021-1-BG01-KA220-HED-000031121, financially supported by the European Commission. The paper is co-funded by the Academy of Finland for the project TOPEILA, Decision Number 350560 which was received by the last author.

8

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10

#### A Multimethod Synthesis of Covid-19 Education Research: The Tight Rope between Covidization and Meaningfulness

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### A Multimethod Synthesis of Covid-19 Education Research: The Tightrope between Covidization and Meaningfulness

#### Abstract

COVID-19 has resulted in significant changes in daily life and one of the areas with the highest impact was Education. Changes were necessary, almost immediately and implied lots of effort. Educational institutions dealt with rapid transitions in different ways, and as a result, a stream of papers regarding insights, impact or guidelines was reported in order to understand and learn from what happened. This study offers a comprehensive analysis of COVID-19 research in education. A multi-methods approach was used, where a bibliometric analysis, pandemic statistics, structural topic modelling, and qualitative synthesis of top papers were combined. A total of 4,201 articles were retrieved from Scopus, mostly published in 2021. In this work special attention is paid to analyzing and synthesizing findings about: (i) status of research about COVID-19 regarding frequencies, venues, publishing countries, (ii) identification of main topics in the COVID-19 research, and (iii) identification of the major themes in most cited articles and their impact on the educational community. Structural topic modelling identified three main groups of topics that were related to education in general, moving to online education, or diverse topics e.g., perceptions, inclusion, medical education, engagement and motivation, well-being, and equality. A deeper analysis of the papers that received most attention revealed that problem understanding was the dominating theme of papers, followed by challenges, impact, guidance, online migration, and tools and resources.

#### Introduction

The last months of 2019 have witnessed an unprecedented situation that humanity has not seen in a hundred years. The initial reactions of disbelief, hesitance and denial have wasted precious opportunities to prepare or at least to take much needed calculated steps [1-3]. Perhaps, the way the situation developed at a staggering speed has made planning practically impossible. Universities around the world, in response to the global pandemic, were forced to cancel their face-to-face classes and shift to online education. Such a decision was taken overnight leading students, teachers, and families to a reality they had to accommodate with the wherewithal at hand [1-4].

Online learning has become the crucial tool for the online transition, lectures were delivered though real-time video conferences e.g., Zoom, Hangouts and Teams [5]. Several other forms were also adopted e.g., video recordings, asynchronous forum discussions, or messaging through emails [3]. Such rapid changes in the way learning was delivered has influenced student satisfaction, mental well-being and a willingness to accept the "new normal" [5]. Teachers had to develop learning materials in new digital forms leading to a large increase in workload and possibly time trying to learn necessary digital skills or use new software [2]. Furthermore, teachers had to develop initiatives that help mitigate the unfolding situation, overcome the limitations of virtual

teaching and possibly improve interactions with students [6, 7]. Families had to be involved in the teaching process, facilitate home schooling and help their children with the stressful situation [8]. Universities created –or we better say improvised– guidelines that detail how to respond to emergency in various shapes or forms e.g., "Emergency Management Plan (EMP)", "Crisis Management Plan," or "Business Continuity Plan (BCP)" containing essentially the four phases of emergency management: preparedness, response, recovery and mitigation [9].

The accelerating situation has led to new realities where the educational community needed novel insights about different aspects e.g., students, teachers, pedagogy, tools, and implementations. Therefore, researchers have been racing to offer their insights regarding their experience, students' perceptions, their tools, and ways to optimize learning and teaching, to mention a few [1, 4, 10]. Funding agencies have also tried to help researchers with fast-track grants targeting education during the pandemic, for instance some Erasmus + calls launched in 2020. To that end, a large volume of research has been produced across vast and diverse areas that requires a synthesis. In this paper, we take a mixed methods approach combining 1) an in-depth qualitative analysis of the top 54 cited papers, 2) a bibliometric analysis of the publication meta-data, 3) we use Structural Topic Models (STM) to make sense of the large number of publications and compile the published research into "topics" which we analyze and offer a concise analysis of the articles content.

Bibliometric analysis offers an overarching quantitative view of scientific research through the analysis of meta-data [11, 12]. Bibliometrics have been used widely across several fields to map scientific productivity, assess impact, dissemination, collaborative patterns, and research trends [13]. This approach relies on several analytical techniques e.g., visualization, network analysis and statistical methods. However, bibliometrics is commonly criticized for the lack of qualitative and nuanced analysis [14]. Therefore, we augment our approach with qualitative analysis of the top 54 cited papers as well as STM for the analysis of research themes [15].

Despite the recency of STM as a technique, STM has gained an increasing role as a valuable tool for studying textual data across social sciences [16, 17]. Using STM, researchers are able to "mine" latent (often referred to as hidden) topics automatically from the large corpora of text using "unsupervised methods" [18]. That is, *topics* are inferred from the text without a priori assignment or manual coding of the data into predefined categories ("supervised methods") [19]. The inferred *topics* represent themes within the dataset that have semantic associations. Two types of models exist, single membership models where each document belongs to a single topic and mixed membership where a document represents a mixture of topics which is used in our study. The use of STM could augment bibliometric analysis through discovery of the research themes and the "hidden topics" [16, 17]. In doing so, STM has an advantage over traditional keyword analysis which are usually dominated by most frequent keywords undermining several important themes within the corpus under study. STM has been used across several studies to reveal predominant research themes e.g., [20–22].

Few bibliometrics studies have tried to cover research about the pandemic e.g., [21, 22]. Yet such studies have focused mostly on online education, used a limited dataset or lacked a nuanced qualitative analysis that synthesizes the results beyond the metrics and indicators e.g., [23]. Our study aims to bridge such gaps. The research questions of this study are:

**RQ1:** What is the status of research about COVID-19 regarding frequencies, dissemination venues, and publishing countries?

**RQ2**: What are the main topics of research in the COVID-19 research and how such topics were discussed?

**RQ3**: What are the major themes in most cited articles and how such themes have informed the educational community about living with the pandemic?

The rest of the paper is structured as follows. The following section presents the methods employed in the study, followed by a section devoted to detailed description of the obtained results regarding each research question with extensive discussion. Finally, conclusions and remarks are presented in the last section.

#### Methods

The search was performed on Scopus database since it has a robust well-curated collection of articles that included almost all of Web of Science with a broader coverage for social science topics relevant to our study [24]. The search keywords were chosen to capture all variations of the Pandemic keyword as well as the education and teaching to reflect the context and therefore we choose the following keywords:

(*covid* OR covid19 OR covid-19 OR CORONA VIRUS OR "SARS-CoV-2") in the title and keywords of all articles and ("*Education*\*" OR "Teach\*") in title, keywords, and abstracts of all articles.

The search for the pandemic keywords involved only titles and keywords, and Scopus categorized keywords. Several iterations of search with different keywords were assessed, in which a sample of articles were assessed for relevance, and accuracy. The final search was decided with consensus among researchers that the keywords bring most relevant results and avoids adding "noise". A decision was made to exclude abstracts from the search for the pandemic keywords since initial searches with abstracts included a large number of irrelevant articles, and thereupon we decided to include articles which authors explicitly stated COVID-19 (or variations of the keyword) relevance through expressing it in the title or the keywords. On the other hand, the education and teaching keywords were searched in article abstracts, keywords, and titles. The keyword learning was also excluded since it has brought lots of irrelevant articles, such as articles related to machine learning.

The search was performed on 15<sup>th</sup> of February 2022 and the meta-data was retrieved, processed, and prepared for analysis.

**To answer RQ1**: Bibliometric analysis was performed using Bibliometrix package [25] which is an open source R package that provides a toolset for analysis of bibliographic meta-data. Frequencies of citations, article statistics and top articles were computed and plotted using R statistical language with the help of Bibliometrix [26]. A non-parametric correlation matrix was created using Spearman's rank correlation coefficient between the number of articles, the citations per article. The correlation was calculated using Spearman correlation with Holm's correction for multiple comparison [19].

To answer RQ2, we have used structural topic modeling (STM). STM has gained an increasing role as a valuable tool for studying textual data across social sciences [16, 17]. Using STM, researchers are able to "mine" latent (often referred to as hidden) topics automatically from the large corpora of text using "unsupervised methods" [18]. That is, *topics* are inferred from the text without a priori assignment or manual coding of the data into predefined categories ("supervised methods") [15, 18]. The inferred *topics* represent themes within the dataset that have semantic associations. Two types of models exist, single membership models where each document belongs to a single topic and mixed membership where a document represents a mixture of topics which is used in our study. The use of STM could augment bibliometric analysis through discovery of the research themes and the "hidden topics" [16, 17]. In doing so, STM has an advantage over traditional keyword analysis which are usually dominated by most frequent keywords undermining several important themes within the corpus under study. STM has been used across several studies to reveal predominant research themes e.g., [18].

To identify the main themes of research through structural topic modeling we used R package *stm* which provides methods for probabilistic topic models, STM in our case. A topic is defined as a mixture of words where each word belongs to a topic with a certain probability. A document could have a mixture of topics i.e., several topics could describe a single document with a certain probability. The *stm* package implements Latent Dirichlet Allocation (LDA) and uses a variational Expectation-Maximization algorithm to estimate the models and their parameters. The topics were modeled using the article's meta-data (title, abstract, keywords) as input [19]. The abstract and title were cleaned from Stop words. Since different keywords may represent the same meaning and could result in erroneous results, we have performed an exhaustive cleaning process where we combined similar keywords together using Google Openrefine [12, 27]. For instance, Learning Management system, LMS, learning management systems were combined together. The cleaning also removed keywords that are used to indicate COVID-19 (e.g., covid, covid19, covid-19 pandemic, Corona Virus) since they were among our search keywords. The estimation of the topic modeling was performed after the cleaning step.

An essential step of topic modeling is in choosing the number of topics. However, there is no optimum way to identify such numbers [28, 29]. Several methods exist to assist in this process, the most recommended of which are Semantic coherence, Exclusivity, and human judgment, which we applied in our study [15]. Semantic coherence is a criterion that is maximized when the most probable words co-occur together and correlates with human judgment. Nevertheless, as

noticed by [19], semantic coherence is often dominated by frequent and common keywords e.g., education and students in our case. Therefore, a measure for the specificity and uniqueness of the keyword was conceptualized to better separate different topics. Exclusivity, as the name suggests, reflects how exclusive the word is in a given topic [30]. Semantic coherence and exclusivity, while offering valuable guidance they "offer no particular statistical guarantees and should not be seen as estimating the "true" number of topics" [19], or as a substitute for careful examination, validation and extensive evaluation by human judgement [28]. Therefore, we followed the guidelines by augmenting the statistical parameters with consensus from experts about the most appropriate number of topics.

We estimated 40 topics the smallest of which had five topics and the largest had 45. The semantic coherence and exclusivity were plotted and examined; ten topics had favorable yet close values. The topics were then examined by four experts who had to rank the best number of topics based on the following criteria [15] :

- 1) the meaningfulness of the topic keywords forming a single theme.
- 2) no significant overlap with other topics
- 3) no significant diversity or dissonance of the representative words.

Each of the experts judged these criteria and the top three topics were examined, discussed and a consensus was reached among the experts that the number of topics that brings unified themes together, with least overlap and dissonance was sixteen topics.

To answer RQ3: The top 70 articles were retrieved according to the number of citations. While our intention was to report on all the 70 articles, we found that some of these articles were very short (less than a full page or just an extended abstract), and had no methods or results section. Therefore, a quality assessment was performed so that very short articles (single page articles), articles without methods or results section, or articles with very small sample size (e.g., n=3) were flagged. The quality criteria were agreed by the three researchers and applied to each of the analyzed papers, when a paper was flagged as a candidate to be excluded by one of the researchers the rest of the authors checked it also in order to make the proper decision and reach a census to exclude the paper. A total of 16 articles were rejected based on a consensus of the three authors and meeting the exclusion criteria. The remaining articles were qualitatively coded according to the themes representing the content of these articles by three researchers. The themes were developed using an inductive or grounded theory approach i.e., developing the themes directly from the articles [29]. Three authors met and coded the articles and reached a census after several iterations on the following themes as representative of the main themes in the data: challenges, guidance, impact, problem understanding, online migration, and tools and resources. In addition, during this classification the target group that the articles were dealing with was also considered i.e., teachers, students.

#### **Results and discussion**

#### **RQ1: The status of research about COVID-19**

The dataset included 4,201 articles, most of which were published in 2021. Three articles were published in 2019, 958 (23%) were published in 2020 and 2,861 were published in 2021. Most of the articles were journal articles 3,310 (78%) with a comparatively low number of conference articles 329 (8%). A total of 12,998 authors contributed to those articles, the majority of them appeared only a single time (93%). Most of the articles in our dataset were collaborative with an average of three authors per document. The USA was on the top of our list of most productive countries in terms of number of articles (21), followed by the United Kingdom with around 7, India 5, Spain, China, and Australia with around 4 of the articles (Figure 1). Yet, the total citations did not mirror the list of top productive countries completely, where we see Spain, Canada in higher positions Table (1).



Figure (1) A world map highlighting the distribution of research productivity. Darker colors represent higher research numbers.

Country	п	Percentage	MCP	Cites	AC
United states	572	21.87	9.09	2897	5.07
United kingdom	190	7.27	20.00	1341	7.06
India	131	5.01	7.63	426	3.25
China	120	4.59	28.33	541	4.51
Australia	118	4.51	21.19	580	4.92
Spain	106	4.05	18.87	920	8.68
Canada	85	3.25	14.12	735	8.65

Table (1) country productivity, citations, and collaboration indicators.

Malaysia	64	2.45	20.31	207	3.23
Saudi Arabia	62	2.37	12.90	267	4.31
Turkey	59	2.26	8.47	131	2.22
Germany	58	2.22	20.69	330	5.69
South Africa	58	2.22	12.07	175	3.02

n = number of articles, MCP = % of articles with other countries AC = average citations per article

#### **Publication venues:**

There have been 1,098 different unique publication venues in the dataset i.e., different journals and conferences. Around 553 (49%) of the venues published only a single article about COVID, 196 (18) published two articles and 104 (9%) published three articles. This diversity in publication venues may reflect the emergent situation where no journals or publications venues were devoted or specialized in such an unprecedented situation. The top publishers in the dataset were open access publishers, some of them have short publication processes [30], and so were the journals that were on the top of our list. Sustainability and Education Sciences from MDPI (Multidisciplinary Digital Publishing Institute) were the top journals publishing around 7% of all articles and had around 10% of all citations. Frontiers in Education published around 2 of all articles and had only 1% of all citations. The rest of the list were dominated by medical education journals e.g., BMC Medical Education, Medical Science Educator, Journal of Dental Education, Academic Medicine. JMIR Medical Education, Advances in Medical Education and Practice and Journal of Surgical Education. The high representation of medical education journals may reflect the fact that medical education involved significant practical work that required students to be in hospitals where the dangers are paramount [6, 31]. Table 2 presents the full list of the top journals that published the papers that were considered in this analysis.

Venue	п	% articles	<i>n</i> Cites	AC	% of Cites
Sustainability	184	4.38	1275	6.93	6.84
Education Sciences	123	2.93	687	5.59	3.69
Frontiers In Education	87	2.07	184	2.11	0.99
BMC Medical Education	73	1.74	533	7.30	2.86
Education And Information Technologies	61	1.45	186	3.05	1.00
Journal Of Chemical Education	55	1.31	402	7.31	2.16
Medical Science Educator	45	1.07	119	2.64	0.64
Prospects	40	0.95	566	14.15	3.04
Journal of Dental Education	36	0.86	400	11.11	2.15
Academic Medicine	30	0.71	154	5.13	0.83
JMIR Medical Education	30	0.71	162	5.40	0.87
Advances In Medical Education and Practice	29	0.69	76	2.62	0.41
EDUCON	28	0.67	16	0.57	0.09
Library Philosophy and Practice	28	0.67	16	0.57	0.09

Table (2) the statistics of the venues regarding number of articles and citation patterns

Journal Of Surgical Education 2	27 (	0.64	664	24.59	3.56
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n = number of articles, AC = average citations per article, % articles percentage of all articles in the datasets, nCites: number of citations, % of Cites percentage of all citations in the dataset.

#### **RQ2:** The main topics of research in the COVID-19 research

A total of 16 topics were identified by the STM, each topic was labelled according to the most probable keywords and the theme representing the topic. The resulting topics were grouped into three main groups of topics: education related, distance/online education and diverse issues related to reaction to the pandemic. The topics are summarized in detail with the most frequent words in Table (3), Figure (2). Below is a concise overview with references from each topic. We use parentheses and bold typeface to highlight the topic to make it easily distinguishable.

Table (3) the top	ic identified by STM and their characteristic words
Label	Frequent words
University	university, online/distance education, professional development, communication, south Africa, parents, literacy
Higher education	higher education, health, resilience, mental, public, early childhood, educational technology
Education	learning/teaching, sustainability, testing/assessment, environment, mathematics, teaching/learning, multimedia
Curriculum	curriculum, distance education, medical education, online, social distancing, assessment, technology
Higher education institutions	higher education, China, institutions, digital, post-digital, 'new normal', community engagement
Distance/online education	
Online education	online/distance education, blended learning, technology, students' perceptions, evaluation, adaptation, practices
Teachers	teachers, pedagogy, crisis, innovation, blended learning, children, management
Remote education	remote, challenge, schools, educational technology, social work education, post-covid, general public
Emergency education	education, emergency, remote, technology, virtual reality, India, experience
School closure	school closures, physical education, social justice, medicine, self-efficacy, home schooling, medical students
Diverse issues	
Perceptions	perceptions, ed-tech, social media, policy, family, descriptive analysis, thematic analysis
Inclusion	inclusion, research, experiences, social, undergraduate, digital competence, qualitative
Medical Education	medical education, technology, simulation, telemedicine, English, culture, strategies

Engagement and motivation	training, student engagement, digital divide, engineering
	education, survey, motivation, quality
Well-being	wellbeing, leadership, social media, stress, equity,
	digitalization, anxiety
Emerging technologies	artificial intelligence, industry 4.0, stem, learning society,
	lifelong learning, fourth industrial revolution, virtual reality
Equality	inequality, policy, global, students, neo-liberalism, digital
	literacy, home

Topic



Figure (2) relative frequency of the sixteen topics in the dataset

Several topics were general, or education related, these include *University*, *Higher education*, *Education*, *Higher education institutions*. These topics addressed the broader context of pandemic and education, the role for higher educational institutions, understanding the "new normal" while also thinking of possibilities for a future pandemic or biological hazards and their impact. Several issues were discussed e.g., internet and infrastructure weaknesses, coping with difficulties, academic career stability, university's financial stability, the complexity of some applied disciplines, student's mental health, and costs of fast transformation and tackling the financial challenges [32, 33].

Distance/online education were among our most discussed topics in the reviewed literature. *School closure* was discussed mainly in the context of the effects of the pandemic on learning and teaching[34–36]. Researchers have highlighted the key role of digital teacher competence in transitioning to *online teaching* [34] and delivering *remote education* as a crisis-response [37]. The crisis situation required an *emergency* response with less complex institutional plans that considered paucity of time and need for immediate execution [40]. Please see **RQ3** for a more elaborate coverage of online education, guidelines for tackling the pandemic including tools, and recommendations.

Several diverse issues have emerged as a reaction to the pandemic. It was obvious that the impact of the pandemic has been unevenly distributed where students with special needs, either physical or psychological needs, were hit the hardest [38, 39], therefore, *Inclusion and equality* have been a concern. Many institutions encountered online teaching/learning for the first time where technical infrastructure, quality of the network, computer availability and teachers' competences had a significant role in the successful transition from offline to digital mediums [42]. While digital infrastructure played a vital role in facilitating the transition in developed countries, students and teachers from undeveloped, remote, and rural areas had problems with poor Internet connectivity, network speed or even a lack of electricity [40–42]. Such challenges resulted in a more pronounced impact, lack of equality and inclusion [38, 43].

Students' *perception* of school closures and the large-scale introduction of online learning, in general, was rather positive [44]. However, research revealed that most students had learning barriers as a consequence of the pandemic, despite the introduced transition instructional techniques [45]. Students' perceptions have also revealed that a mismatch could happen between students' expectations and teachers' managing online learning [46].

As distance learning prevailed during the times of rising infection rates, students' *engagement, and motivation* was an issue. Studying from home required greater self-discipline to follow through with online lessons. On the other hand, lecturers' unfamiliarity with the new mode of delivery could burden their students with study materials and assignments. The lack of social interactions, lockdown and restricted physical activities were not easy for the young generations [47]. Such a heavy psychological toll has prompted several scholars to investigate issues of students' *well-being* and mental health during the pandemic. Research has shown that most students' population has been under mental and psychological stress [48]. Several articles have investigated the factors that help students handle the unusual situation e.g., autonomy and competence  $[49]_{2}$  or how to offer mental and psychological support to students during the pandemic, offering methods of enhancing interactivity and social support [50]. Such mental support was investigated across all stakeholders e.g., students, teachers and families [50]. This transformation has forged a stronger connection between teachers and parents than ever before [51].

*Medical education* (including dental and nursing education) was among the most discussed topics, and medical education journals dominated the list of our top venues. Several articles discussed the dilemma of the need to train future healthcare professionals in hospitals (where the risk of infection

is high) while still protecting the students, teachers and patients [6, 31]. The issue was discussed widely across the world e.g., in the United Kingdom [52], in China [53] and in the USA. Other articles discussed medical students' contributions to the delivery of care where healthcare services were restrained [54].

#### **RQ3:** Top cited papers

As commented in the previous section from our top 70 most cited papers 54 were selected and classified according to 6 different themes: challenges, guidance, impact, problem understanding, online migration, and tools and resources. The category *problem understanding* has 26 contributions, which was the highest number of all other themes. *Challenges* and *impact* had 16 contributions each, while *guidance*, *online migration* and *tools and resources* had 14, 13, and 10 contributions, respectively. Table 4 presents most common findings in the analyzed most cited papers for each category.

Problem understanding		
Teachers' issues	Students' issues	Other issues
There is a need to develop digital competence [5, 34, 55– 58]. Improve student-teacher interaction [50, 56, 58].	Digital divide: Need of ICT infrastructure [63, 64] sometimes with a high cost [44, 65]. Should find ways to cope with	Need for a pedagogical approach that relies heavily on the social and collaborative components of learning [55]. Distance learning is seen as a
Equip the teachers also with socio-affective competences [55]. Willingness to change to	stress and anxiety due to the new situation and provide them with tools and experts to support them with the situation [5, 50, 63].	solution but with the barriers of the need of technological infrastructure and with a high acceptance if there students have a previous experience
online and apply new techniques and methodologies [58, 59].	Availability ICT for disadvantaged students [50] or for students in different	with it [64]. Parents' anxiety and need to educate from home [36].
Assessment difficulty and need for possible adaptations [59, 60].	contexts [63, 66, 67]. In practical disciplines such as medicine and especially at	Mentoring methods are more flexible and sophisticated approaches in order to
Importance of making personal connections and increasing student interaction [61].	some moments enhanced virtual curriculum development is required and this could affect the specialty	enhance the potential of new spaces for teaching and learning to teach [71].
Teaching experience and specialization is very strongly correlated to readiness to	choice [68, 69]. Efficiency of live online courses was unsatisfactory among students. However,	

Table (4). The most common findings in top 54 cited studies for each theme

distance learning education [62]. Teachers' geographic location is strongly correlated to readiness to adapt to distance learning education [62].	when live online courses are combined with the flipped classroom it improves [70]. Improve communication with teachers and students [57, 70]. Higher workload [5, 6, 33, 41, 68].	
Challenges	Impact	Guidance
Teachers and students had to deal with anxiety and frustrations [5, 6, 37, 45, 72].	Impact on students' academic work and personal lives [5, 50, 57, 63, 72, 73].	Adjusting teaching to remote/emergency learning, [56, 71, 84, 85].
Both students [5, 73] and teachers [4, 51, 74] reported	Students' satisfaction with the role of their university [61, 77,	Posting materials online [3, 67, 74].
and lack of computer skills	[78]. Impact on students'	Providing regular feedback [35, 55, 71, 75].
Need for substituting hands- on learning and conducting	confidence and their preparedness for the next steps in their studies [52, 68].	Maintaining online interaction [35, 55, 56, 84, 86].
praxis virtually [6, 64, 71, 74, 75].	Students' perception about the quality and effectiveness of	Providing practical training through distance learning [3, 71, 82, 85].
Many depended on family members to help them to adapt to the online environment [51].	different teaching and learning approaches and experiences [44, 50, 52, 73, 79].	Establishing targeted communications for the reassurances of parents and atudanta [2, 25, 85]
Challenge of student retention and student recruitments [4, 51, 76].	Impact on teachers' planning, teaching, and workload [35, 65].	Making a use of open educational resources and
Lack of motivation and presence of boredom [45, 66, 77]	Impact on the digital divide among different socio- demographic	Learning how to cope with the stress [87].
Lack of technical and infrastructural resources [45, 64, 67, 78].	communities/groups [5, 63, 80]. Impact on the transformation	Using active learning pedagogical approaches, along with simulations and
Teachers might not be	of online education [65, 81,	videos [3, 74].
familiar with the process of choosing the most suitable resources [78].	<ul><li>82].</li><li>Impact on student interest to study overseas [83].</li></ul>	Using diversified and individualized assessments [35, 82].
Some have questioned whether the digitalization of higher education was too aggressive and if it will leave	Impact on the readiness of educational institutions for distance education [62].	Using flexible teaching and assessment methodologies [86].

a negative prejudice on future distance learning [48, 64]. Need for complex cognitive and social skills that underpin success in online-learning environments [61]. Academic performance of	Develop the system for quality assurance of e- learning [80]. Establishing support systems for the faculty and students on the institutional level [88].
Academic performance of students may be affected by socio-demographics [37, 76].	
Online migration	

Online migration	
Interventions	Implications of the change
Optimism as part of the faculty readiness to the change and willingness in sharing power in the class with students [59].	Technical, infrastructural resources and student barriers as key issues for the success of distance learning [64] [66].
Need to adapt assessment [59, 84].	COVID-19 as a way to launch online learning
Technological solutions not always driven by best pedagogical practices [89].	initiatives at different educational levels [4, 81].
Possibility to integrate external tools in the institution or to export data to facilitate the use of such tools [37].	Need of professional development designers to overcome the main problems related with the pandemic situation such as equal access to online learning by students and managing
Necessity to deal with factors such as: technology availability, work at home, heavy workload digital competence assessment and	demands of the stakeholders in the educational process [4, 59].
supervision and compatibility [37, 51, 84].	Emergency remote teaching is not the same as online learning but the experience obtained
Necessity to provide the young generation with digital skills and to avoid the different	will lead to a future more sustainable online learning [37].
Online university teaching requires to design activities taking into account the new reality about presence (social, cognitive and facilitatory) [84].	The impact in not only academy but student recruitment, market sustainability, an academic labor-market, and local economies [74].

#### **Tools and resources**

Tools and resources related to medical education [74, 75].

Description about the asynchronous and synchronous tools and approaches followed and lessons learned [77]. The type of tools provided by the government in the COVID-19 situation, with access to free educational tools and contents and even using tools not created for educational purposes [81].

The importance of using securitization theory during emergency learning [90].

The use of open educational resources (OER) and open educational practices (OEP) as effective tools in COVID-19 situation [78].

Studies related to tools use and success such as: frameworks to assess educational portal success [80]; adaption of acceptance model to evaluate the acceptance of LMSs [91]; or study of the impact of the pandemic situation in user experience with several educational platforms in China [79].

Analysis of the coping strategies with stress levels reported by teachers [87].

The use of social media to facilitate interaction between teachers and students in COVID-19 situations and future implications [92].

The research carried out covers several issues that are related among them. The first one, "problem understanding" is something essential in most of the research evaluated. The problems were addressed from a local perspective [42, 57, 64, 68, 91], to a global point of view [5], passing through regional or local approaches [32, 34, 48, 56, 66, 67], [50, 55, 58–60, 62, 65, 69]. They deal with the stakeholders perspectives [5, 32, 42, 48, 53, 55, 57, 59, 60, 62, 69] and other deals with varied topics related with the context or the conditions in which the activity is carried out [5, 48, 50, 62, 64–67, 91], [54, 61, 63, 92] or the methodologies or solutions employed [53, 56, 59, 64, 68, 69, 87].

Regarding the "challenges" explored there is great variety. We can summarize them as how the COVID-19 requires changes in educational processes [4, 6, 43, 49, 62, 65, 69, 72–74, 76] and how prepared for this are students, teachers, and other stakeholders [4–6, 35, 43, 49, 64, 70–72, 75]. All the stakeholders are required to develop computer skills [64] and need the infrastructure [43, 62, 65, 76] to conduct the teaching and learning in an online way.

The COVID-19 "impacts" at several levels. In the compatibility between the academic and personal live [5, 48, 55, 61, 70, 71], in how teaching is carried out [42, 48, 50, 71, 77] and the associated workload [33, 63], in the transformation of online education [63, 79, 80] and in how must universities adapt to the new context [5] and distance education [60].

Another important issue to be explored in this review is the "online migration." It depends on the context as described above. Some discuss the interventions carried out [43, 56, 59, 75, 93] while others focused more on the implications of this change [4, 35, 57, 62, 64, 79, 82].

Regarding the "guidance" proposed in several study cases some of them are related to teaching materials and methodologies [54, 69, 82, 83], the interaction with students and parents [3, 33, 53, 54, 69, 72, 73, 76, 82–84], ways on providing practical training [3, 69, 80, 83], assessments [33, 80, 84], ways of dealing with the stress [85] and institutional support development [78, 86].

Finally, when exploring the tools and resources used during COVID-19 it is important to take into account that they can depend on the context. For instance, in medical training it could be necessary to take into account how to maintain patient contact, contact with medical experts, develop peermentoring techniques, etc. [72, 73]. But in common contexts the most relevant tools and resources are related with the interaction strategies with students [75, 79, 90], the type of resources used during the classes [76], assessment tools [78, 85], and educational platforms [77, 89].

#### **Reflections and Conclusions**

We have conducted this study with the aim of offering an overarching synthesis of COVID-19 research from the pandemic onslaught till now. A mixed methods approach was used, where we combined quantitative analysis of research productivity with pandemic statistics, structural topic modelling and qualitative synthesis of papers with most attention from the educational community. There are several key findings that warrant reflections.

The analysis has shown that the process of knowledge production about COVID-19 was less skewed compared to educational research in general [12, 96], with a large global participation of 137 different countries in research productivity. Whereas, research was concentrated in large and resourceful countries such as United States [36, 58, 68, 69], China [78], India [50], Germany [34], United Kingdom [52]; we also see several studies that have addressed local and non-western contexts e.g., Philippines [62], Rural South Africa [66], Jordan [64], Romania [57], Indonesia [67]. In fact, a global perspective [47, 65], with wide participation from different countries has helped in understanding the full breadth of impact of the pandemic [40, 42, 64]. In doing so, issues such as inequalities among different students' subpopulations, as well as disparities in infrastructure and access to internet in e.g., rural areas, have received global attention and were prioritized [38, 43].

Several papers have targeted teachers and teacher education [59, 62, 71], others have addressed students [50, 57, 64], yet, very few have researched the perspective of the families, despite that families were heavily involved in the process [51, 69]. Noticeable also that research was rather skewed towards some research fields, where medical [52, 64, 68, 69], engineering and mathematics education [46], [67, 93] have received significant attention from researchers. A finding that could be explained by the idea that such disciplines may require practical face-to-face teaching which was an issue of concern during the pandemic [6, 31].

School closure, the consequences, and the alternative solutions have occupied the public discourse as well as the research communities. Yet, schools have gone through several stages. Initially, many countries rushed to school closure which peaked around April 2020. About 1.3 billion students (81.8% of all enrolled) were instructed to stay home; a year later, where the pandemic was more rampant, school closure affected only 12.7% of students, reaching 2.7% as per the last recording in February 2022. Perhaps, the loss of learning time, the heavy toll on learners' well-being as well as the remarkable burden vulnerable students had to endure [8, 49], has led to a policy where schools "were last to close and first to open" to avoid what the UNESCO called "a generational catastrophe." Such a potential catastrophe would have resulted in stark inequalities of learning opportunities but also other aspects that school provides e.g., school meals, physical activities and social interaction [38, 40–42]. Of course, such decisions were aided by prioritizing teacher vaccination, health measures and infection tracing [40, 48].

If anything, the pandemic is known for, it is the "impact", an issue that has been studied from all the point of views, sides, and perspectives. Therefore, researchers have intensively studied the impact of pandemic on workload [35], academic work and personal lives [5, 57], student satisfaction [4, 77], confidence [52], quality of teaching and learning [44, 52] and on vulnerable groups [5, 63]. The impact on mental health and well-being has been a central theme in the pandemic research [8, 48, 50]. Along with the impact, came a long list of articles of recommendations and guidance regarding how to mitigate the impact, or address the challenges. For instance, we saw discussion about technical infrastructure [34] [41], online learning initiatives [4, 81], or sustainable online learning [37].

The rush to move online has been accompanied by an accelerating stream of articles about the pandemic [97]. Thoughtful, well-planned, and meaningful research was hard to conceptualize or implement, and a sense of urgency led to a deluge of research with thin contributions in a time of dire need to genuine insights [97–99]. Perhaps, as it has been argued by [97, 100], some may have found an opportune time to jump on the bandwagon of COVID-19 and the possibilities for research funding to capitalize on the need for research about the pandemic, a phenomenon that later became known as Covidization of research [97, 100].

We have used two methods for the analysis: STM and thematic analysis of the top cited papers. While STM is well-established for summarizing the general themes of a large textual dataset, such summarizing power should not be confused with retrieving the "true" content of the documents. As [28] points out, automated text analysis should not substitute careful and thoughtful text examination. Therefore, such methods are "best thought of as amplifying and augmenting careful reading and thoughtful analysis" [28]. Therefore, a qualitative thematic analysis was performed, which revealed related but also varying themes. Of those themes, some may be hard to pick with a summarizing automatic text analysis e.g., problem understanding, implications of the change and challenges. As such, we suggest that a careful qualitative analysis may be helpful to draw the full picture of text analysis.

Our article is not without limitations. Our search using keywords – which is the standard in all systematic reviews and bibliometrics – may have missed some articles that did not explicitly mention the pandemic keywords. Therefore, our results should not be viewed as encompassing all literature, but a large collection of articles based on systematic search. Using citations as measures of article impact is not ideal, yet it remains to be the most followed practice in the literature. To compensate for such shortcoming, we have used structural topic modelling to gather all relevant topics and insights from the literature. One may not expect that synthesizing a few thousands of papers in a single article can be exhaustive, comprehensive, or complete. Nonetheless, our results should be viewed as a summary of the "important" take-home messages from these articles. Bibliometrics methods have known deficiencies such as over-reliance on metrics and skewed quantification of research which we tried to avoid in our article by combining several methods. The recency of the pandemic does not allow an accurate estimation of the impact of research or a temporal timeline and therefore, our estimation of such aspects remains to be verified in future research. Last, relying on a single database may have missed some articles that are not indexed in

Scopus. Nevertheless, we had to choose one database to avoid erroneous mixing of citation counts between databases, and we selected Scopus since it has the widest coverage. Another limitation for our study is reliance on a database with poor selection of articles from the global south, a problem that all databases suffer from.

#### Conclusions

This work provides synthesis of COVID-19 research published by the educational community. A combination of quantitative analysis of research productivity with pandemic statistics, structural topic modelling and qualitative synthesis of papers with most attention from the educational community was used. A large volume of knowledge has been produced in education over the past couple of years that addressed various aspects of the pandemic, the majority of which had been published in open access journals, and few were in well-established publication outlets. From all papers that were taken into account, three main groups of topics were identified: (i) topics relating to education in general, (ii) topics dealing with migration to online education, and (iii) diverse topics e.g., perceptions, inclusion, medical education, engagement and motivation, well-being, and equality. A deeper analysis of the most cited papers revealed that problem understanding was the dominating theme of papers, followed by challenges, impact, guidance, online migration and tools and resources. While the conducted analysis may not be viewed as all encompassing, as some papers may have been missed by using one database, it does give an important synthesis of the findings in a large volume of knowledge as the insights were drawn from multiple perspectives and using different methods.

#### Acknowledgments: NA

#### **Funding information**

The work presented here was co-funded by the [Blinded for peer review]

#### **Conflict of interest**

The authors have nothing to declare

Availability of data

The data in this manuscript is available with reasonable request given the licenser approval **References** 

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