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Blended Learning Approach to Engineering Education: Students' Perceptions on Learning Experience and Effectiveness

Koneru Indira
Associate Dean & Head, eLearning Department Icfai Business School
#65, Nagarjuna Hills
Hyderabad – 500 082
indkon@gmail.com, indira.koneru@ibsindia.org

Abstract: The impact study conducted in a residential engineering university in rural India evaluated the effect of blended learning (BL) on the Engineering students' learning experience and effectiveness. Data collected through the post-course student survey and students' performance scores in the end-of-semester examination helped in understanding students' perceptions on blended learning and analysing blended learning effectiveness. Though the t-test results of achievement comparison between BL students and non-BL students' were mixed; the perceptions of students leaned in favour of blended learning. This paper presents the Engineering students' perceptions towards blended learning experience and effectiveness of their teachers' blended instructional practices and the correlation between students' blended learning satisfaction and achievement.

Keywords: Blending learning, Course design, Engineering education, Learning management system, Impact study, Moodle

Koneru Indira[1]
eLearning Department Icfai Business School
#65, Nagarjuna Hills
Hyderabad – 500 082
indkon@gmail.com, indira.koneru@ibsindia.org

1. Introduction

In India, 3,500 institutions are disseminating engineering education. Barring the Indian Institutes of Technology (IITs), other Engineering Institutes are struggling with a critical shortage of qualified and quality teachers, low enrolment, lower placements, and low employability, resulting in a dearth of quality professionals and poor employability of engineering graduates (Cutrell et al., 2015; AICTE, 2019). In order to improve the situation, the report of the AICTE's Committee for "Preparing Short & Medium Term Perspective Plan for Engineering Education in India" (2019) recommends technology interventions, innovations in pedagogy, such as blending MOOCs with core and optional curricula, providing individual learning path for each student. Though, Indian Engineering colleges have been using National Programme on Technology Enhanced Learning (NPTEL) videos in teaching, clear implementation guidelines are not provided to adopt curriculum-integrated approach nor there have been any blended learning impact studies to suggest evidence-based blended learning practice that can improve learning outcomes in engineering education in India (Cutrell et al., 2015). To address the above-mentioned issues, Commonwealth of Learning (COL, n. d.) through its "Policy–Technology–Capacity" advocacy, provided the needed support to Rajiv Gandhi University of Knowledge Technologies (RGUKT).

The study "Impact of Technology-Enabled Learning Implementation at Rajiv Gandhi University of Knowledge Technologies" (Indira, 2019) evaluated the impact of blended learning (BL) on the Engineering students' learning experience and learning outcomes and their teachers' instructional strategies. This paper presents the Engineering students' perceptions towards blended learning experience and effectiveness of their teachers' blended course design and instructional practices and the correlation between students' blended learning satisfaction and achievement.

2. Background

The Government of Andhra Pradesh established the Rajiv Gandhi University of Knowledge Technologies (RGUKT) in 2008 for providing Engineering education opportunities for the deprived rural youths through the 6-year integrated Engineering programme – 2-Year PUC / Pre University Course and 4-Year B. Tech. / Bachelor of Technology (undergraduate) from four campuses, namely, Nuzvid, RK Valley, Srikakulam and Ongole. The university provides each student and teacher with a laptop and broadband connectivity for officials, teachers, learners, researchers and visitors.

The University's ICT-based pedagogy provided students with access to video lectures, Open Educational Resources (OER) and other eContent through the local content servers, but not through the Learning Management System for anytime and anywhere access. Most of the teachers use word processing, spreadsheets, presentations, email, search engines and databases. However, they lack in advanced digital content creations skills such as graphics editing, multimedia authoring, digital audio, video editing, Web design and LMS skills (Venkaiah, 2017). In order to adopt a blended learning approach to strengthen the existing ICT- based pedagogy and improve the quality of student-content, student-student and student-teacher interaction and students' learning outcomes, RGUKT partnered with Commonwealth of Learning (COL).COL's support helped the RGUKT in: (i) conducting a baseline study on TEL; (ii) developing a TEL policy for blending appropriate technologies with teaching-learning; (iii) building capacity among the teachers to design, develop and deliver blended learning courses through Moodle; and (iv)undertaking an impact study.

3. Review of Literature

Blended learning, a combination of traditional F2F learning systems and distributed learning systems emphasises the central role of computer-based technologies in teaching- learning (Graham, 2006). As a formal education programme, blended learning combines online with face-to-face teaching-learning in a pedagogically valuable way to increase student engagement in the learning process and to improve student control over the time, place, pace and path of learning (Kenney & Newcombe, 2011; Christensen, Horn and Staker, 2013).

Blended learning as a techno-pedagogical innovation (Chafiq N., Housni M., Moussetad M., 2019) facilitates teachers create an enabling digital learning environment and design learning experience through the organic integration of thoughtfully selected face-to-face and online approaches (Vaughan, Garrison, & Cleveland, 2013). Students learning experience in a blended learning environment largely depends on (i) pedagogical richness of a blended course that improves student engagement in autonomous, co-operative, collaborative, constructive and interactive learning and (ii) technological ease that facilitates convenient and flexible learning opportunities.

Quality, reliability and availability of the system used and the ease at which students access and navigate the LMS, its tools and course content and technology orientation play a major role in blended learning success (Piccoli, Ahmad, & Ives, 2001; Kintu, Zhu & Kagambe, 2017; Hofmann, 2014). Convenience, efficient use of time, flexibility, course content, learner interface, reflection, interaction and relationships with peers and teachers, collaboration and feedback, combined synchronous and asynchronous communication tended to report more positive effect on blended student perception and satisfaction (Tobin, 1998; Chang & Fisher, 2003; Shee & Wang, 2008; U.S. Department of Education, 2010). Finding appropriate technology to create an enabling blended learning environment and identifying tools to engage students in learning interactions with the content, instructor and peers are vital to have a positive impact on student achievement.

4. Blended Learning Environment

Creating a blended learning environment

necessitates providing access to technology; adequate and timely support and building technological and pedagogical capacity amongst the staff (Cook, Giardina, 2011). A blended learning environment necessitates teachers to assume the role of an instructional and/or learning designer. At RGUKT, a blended learning environment was created using Moodle1 (Modular Object-Oriented Dynamic Learning Environment), an open source LMS (Learning Management System).

Moodle hosted on the RGUKT local server2 facilitated the teachers to blend F2F teaching with online learning; create flexible learning environment; share and manage content in multiple media; create activities and assessments; grade students' performance and provide feedback; communicate online and offline learning events with students; and engage students in collaborative and constructive learning tasks (Indira, 2015). Eighteen Moodle-enabled blended courses were offered to the Pre-University Course (PUC) and Engineering undergraduate students during the January– April 2018 semester.

The two capacity building workshops on blended course design, Moodle functionality, open educational resources (OER), screen-casting videos, blended course development etc. enabled the RGUKT teachers to:

- redesign their courses using the backward design (Wiggins & McTighe, 2002) and/or constructive alignment (Biggs, 2003) approach;
- structure the online course week-wise or unit-wise;
- write course and unit learning outcomes;
- self-record the course introductory video and Face/Flip (Ruffini, n.d.) videos using Screencast-O-Matic3; publish on YouTube; and embed in the Moodle course in order to orient students towards the blended environment, provide online learning support and have pedagogical effectiveness on learning (Garner, 2008; Pang, 2009);
- create assessments, such as file submission and video-based assignments, such as ANSYS/Autodesk Inventor, professional software- based assignments and self-assessment quizzes for creating a test series environment;
- engage students in interaction through activities, such as forums and chat;
- promote leaner-content interaction by creating interactive videos using the H5P plugin4 to increase learner engagement and enhance learner control over the content and process (Zhang, 2005);
- cover and share more materials (Karabulut-Ilgu, Jaramillo Cherrez & Jahren, 2018);
- share and/or crate learning resources in a variety of media, including Khan Academy videos, animated videos, video tutorials (on ANSYS 2D Modelling, ANSYS 3D Modelling, ANSYS Meshing) and open educational resources (OER), such as NPTEL5 and PhET6 Interactive Simulations;
- track students' learning progress and course participation;

[5] National Programme on Technology Enhanced Learning, a project funded by the Ministry of HRD offers multimedia- based material and courses for basic undergraduate Science and Engineering courses. https://nptel.ac.in/

[6] PhET Interactive Simulations project at the University of Colorado Boulder creates free interactive math and science simulations. Journal of Engineering Education Transformations, Volume , No, Month 2015, ISSN 2349-2473, eISSN 2394-1707

- grade students' performance and provide feedback;
- communicate with and send bulk and individual messages and alerts to students through Moodle course and Moodle mobile app; and
- take maximum advantage of the benefits of digital delivery (Bailey, 2018).

90–100% of the BL teachers valued that the capacity- building workshops helped them in understanding and integrating Moodle functionality with the blended course design and in developing online course as per the course design. They also noted that the COL Facilitator's post- workshop mentoring through the WhatsApp group, e-mail and phone had helped them throughout their blended teaching-

learning journey, i.e., from blended course design through evaluation.

5. Research Questions

The study formulated the following research questions to investigate the impact of blended learning on students' learning experience and effectiveness.

- How do learners perceive the effectiveness of the blended learning environment in their course of study?
- How does teacher practice affect student perception of blended learning courses?
- How do students perceive their teachers' practice and behaviour in a blended learning environment?
- How do perceptions of learning in blended courses relate to achievement?

6. Research Method

The study collected data through a survey on students' perceptions and satisfaction about their blended learning experience and effectiveness and students' performance data in the end-of-semester examinations. To analyse the differences in students' academic achievement, the students' scores in the January–April 2018 semester BL courses were compared with the scores of students in the January–April semesters of 2016 and 2017 taught by the same faculty. The intention was to compare the blended courses with the traditional courses offered by the same teacher who had followed the same curriculum assuming that the students in different batches had similar characteristics.

A. Sample

The study sample included the 1632 blended learning students from 18 blended learning courses developed in Chemistry, Chemical Engineering, Computer Science, Civil Engineering, Electronics and Communications Engineering, Humanities and Mechanical Engineering disciplines. The student sample was not randomized, as the research was limited to the 18 blended learning courses. Therefore, there may be a self-selection bias in the results of this study.

B. Survey Instrument

The student post-course survey questionnaire was developed by adapting some questions from Owston, York, & Murtha (2013). The instrument comprised of demographic questions; questions on the blended learning courses delivered; student evaluation of the quality of blended course teaching; and on overall blended learning satisfaction. The students rated their perception and satisfaction on a five-point scale of either “Excellent” (5) to “Poor” (1) or “Strongly Agree” (5) to “Strongly Disagree” (1). The reliability and internal consistency of the survey instrument was measured using Cronbach's (1951) alpha coefficient. The values ranged from 0.89 to 0.80 exceeded the accepted level of 0.70.

A. Data Analysis

The quantitative data obtained from students' online survey responses about blended learning effectiveness and satisfaction, and from students' end-of-semester results, were analysed through descriptive and inferential statistics. The two-sample t-test assuming unequal variances was used to determine the relationship between students' education level and their perception of blended teaching practices. ANOVA tests helped in comparing students' level of satisfaction with their achievement, among and between groups.

7. Findings

Out of 1,632 blended learning students (See Table 1), 730 (44.73%) were male, whereas 902 (55.27%) were female. 909 (55.7%) students were from

Table 1: Demographic and academic profile of respondents

Programme of Study & Gender	RGUKT Nuzvid Campus	RGUKT RK Valley Campus	Total
B. Tech.	598 (54%)	311 (60%)	909
Female	385 (64%)	80 (26%)	465
Male	213 (36%)	231 (74%)	444
PUC	514 (46%)	209 (40%)	723
Female	309 (60%)	128 (61%)	437
Male	205 (40%)	81 (39%)	286
Total	1112 (68%)	520 (32%)	1632

Bachelor of Technology /B. Tech. (undergraduate) programme and 723 (44.3%) were from the Pre University Course / PUC.

A. Effectiveness of Blended-Learning Environment

For measuring blended learning effectiveness, various studies used performance related indicators, such as learners' grades comparison, course completion and their success (Garrison & Kanuka, 2004; Kenney & Newcombe, 2011; Renner, Laumer & Weitzel, 2014). However, in addition to performance, this study looked into the other co-curricular outcomes, namely, improved digital literacy, flexibility, time management, learning experience that complement their blended learning experience. The first research question "How do learners describe the effectiveness of the blended-learning environment in their course of study?" sought students' perceptions on the afore-mentioned indicators.81% to 91% students had positive perception on the overall effectiveness of blended learning environment. 84.8% students perceived that blended learning improved their digital literacy. 91.16% agreed that information technology helped them to learn and 86.27% appreciated that the LMS-enabled multimedia resources enriched their learning experience. 83.45% valued that interacting and communicating synchronously and asynchronously with students and faculty improved their learning and 81.42% agreed that blended learning improved their time management skills. 85.51% perceived to have greater convenience and flexibility to regulate their pace of study of course materials and their participation in activities. 85.21% were satisfied with the use of Moodle mobile app for viewing / reading learning resources; interacting with faculty and peers; and submitting assignments and quizzes. 82.16% agreed that blended learning improved their performance in mid-semester examinations.

From the data, it was evident that students appreciate a blended learning environment that provides greater access to knowledge, greater engagement in interaction with peers and teachers; greater convenience and flexibility; a higher level of autonomy to regulate their own study of course materials and to set the pace of their participation in online discussions and synchronous and asynchronous communication. (Chang & Fisher, 2003; Shee & Wang, 2008; Tobin, 1998; U.S. Department of Education, 2010; Larsen, 2012; Owston, York & Murtha, 2013).

A further analysis was made to ascertain whether gender and level of study make a difference in perception of the effectiveness of the BL environment.

The independent t-test results conducted on all aspects of BL effectiveness suggest that there is a difference in the perceptions of male and female students about BL effectiveness. Male students had more positive perceptions than female students.

B. Student Perceptions of Teacher Course Design and Delivery Practices

Research question 2 and 3 sought the blended learning students' perceptions on their teacher's blended course design and delivery practices. The second research question "How does teacher practice affect student perception of blended learning courses?" measured students' perception of teachers' blended course design and delivery.

A blended learning approach necessitates teachers to rethink course design, development and delivery practices to help students understand the course overview, learning objectives, assessment and evaluation, instructional materials, activities, course technology, learner interactions, learner support, accessibility and usability. Teachers' attitudes and beliefs, their willingness to try new teaching methods, and their use of a balanced mixture of synchronous and asynchronous communication are all key factors in a successful BL course (Alammary, Carbone & Sheard, 2015; Owston & York, 2018; Quality Matters, n.d.).

The students' perception mean to the various questions ranging between 3.84 and 4.06 indicate that students had a highly positive perception towards blended course design. 60-70% of the students' perceived their teachers as effective course designers and deliverers. They were good at describing the course, its learning objectives, activities and assignments (mean=3.92), communicating information (mean=3.91) and expected performance in activities (mean=3.89), overall organization of the course (mean=4.06), making learning resources available in multimedia (mean=3.9), blending face-to-face with online learning (mean=3.89), maintaining the pace of the course (mean=3.84) made their learning effective.

ANOVA test was run to ascertain whether students' perceptions differed between blended courses. The

Table 2: Comparing students' perceptions among blended courses (ANOVA)

Source of Variation	*SS*	*df*	*MS*	*F*	*p-value*	*F-crit.*
Between groups	8.13	17	0.48	35.08	3.81E -36	1.718 165
Within groups	1.47	108	0.014			
Total	9.60	125				

results in Table 2 with F value more than the F-critical value and a p value less than 0.05 indicate that the students' perceptions of the blended course design statistically differed among the various blended courses.

To seek answers to the third research question "How do students perceive their teachers' practices and behaviour in a blended-learning environment?", students were asked to rate their teachers' blended teaching practice and interest in students' learning; tracking of their learning progress; alerting students; providing orientation and feedback; and stimulating students' interest.

Students response to the 'overall experience of the course' (mean= 4.01) indicate that students had a highly positive perception on their teachers' blended teaching practice and behaviour. 60%-70% of the respondents perceived that their Faculty showed interest in their learning (mean=4.2), stimulated their interest in blended course (mean=4.06), tracked their learning progress and sent alerts (mean= 4.14), provided feedback on their performance (mean=3.98) and orientation (mean= 4.03) and were available in-class and online (mean=4.03) for needed support. All BL teachers provided in-class orientation to the students and some teachers even engaged student ambassadors for promoting blended learning.

C. Students' perception on teachers' blended teaching practice

A blended teaching-learning approach requires teachers to rethink their course design to enable students understand the course overview, learning objectives, assessment and measurement, instructional materials, activities, course technology, learner interactions, learner support, accessibility and usability. Teachers' attitudes and beliefs, their willingness to try new teaching methods, and their use of a balanced mixture of synchronous and asynchronous communication are all key factors in a successful BL course (Alammary, Sheard & Carbone, 2014; Owston & York, 2018; Quality Matters, n.d.). This research question "How does teacher practice affect students' perception of blended- learning courses?" adapted some of these criteria to ascertain students' perception of teachers' blended learning course design and delivery practices 60–70% of the students perceived their teachers as effective at describing the course, its learning objectives, activities and assignments (mean = 3.92), communicating information (mean = 3.91) and expected performance in activities (mean = 3.89), organising the course overall (mean = 4.06), making learning resources available in multimedia formats (mean = 3.9), blending F2F with online learning (mean = 3.89) and maintaining the pace of the course (mean = 3.84). Further analysis of the data helped to ascertain differences in perceptions between PUC and B. Tech. students.

A t-test was administered with a significance level of 0.05 to find out whether the students' perception of blended teaching practice differed between PUC and B. Tech. students. The p-value in Table 3 indicates there was no significant difference between PUC and B. Tech. students' perceptions of the BL course design and teaching practices except for one: the teacher's communication of ideas and information in the course.

Table 3 : Relationship between education level and students' perception of blended teaching practices

Dimensions of blended teaching practice	**t**	**p**
Description of course objectives, learning activities and assignments in the online course	**1.90**	**0.06***
Communication of ideas and information in the course	**2.04**	**0.04**
Expression of expectations for performance (e.g., online forums, assignments and quizzes) in the course	**0.83**	**0.41***
The instructor's overall organisation of the course	**– 0.78**	**0.44***
Online learning resources made available within the LMS	**– 0.49**	**0.63***
Continuity between F2F class and online learning	**0.27**	**0.78***
Pace of the course	**1.48**	**0.14**

* p = < 0.05

D. Achievement in Blended Courses

Similar to other impact studies, the study considered student grades obtained and/or improved as an indicator to establish the effectiveness of blended learning. The t test was used to measure "How is the learning achievement in blended learning course different from other courses in the university?" To analyse the differences in students' academic achievement, the scores of the 2018 January–April semester BL students were compared with the scores of students in the January–April semesters of 2016 and 2017 taught by the same faculty with the same curriculum.

The comparison of mean achievement scores of BL students and Non-BL students showed a mixed result. The following chart (Fig. 1) indicates that there was an improvement in students' achievement in nine courses and no improvement in nine courses.

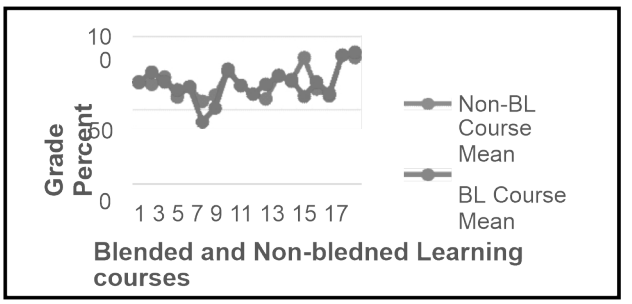

Fig. 1: Blended learning courses and non-blended learning courses

The *t* test results in Table 4 indicate that the difference in grades were statistically significant in nine courses (50%): Chemistry (P2S2), Computer Organisation & Architecture, Design of Machine Elements II, Engineering Mathematics 1, Foundation Engineering, Heat Transfer Chemical Engineering, Mass Transfer Operations-II, Natural Language Processing, and Telugu PUC P2S2 and no significant difference in the other nine courses (50%).

Further analysis of blended course design and delivery of the 18 blended courses helped in understanding the reasons for negative or zero impact of blended learning on students'achievement and identify the difference (if any) in the course design, content sharing, structured activities and course-delivery patterns that optimised student engagement (Dziuban, Moskal & Hartman, 2005; Garrison & Vaughan, 2008; Owston & York, 2018).

No major difference in the organisation and structure of the Moodle courses was detected, as all the courses had an introductory video/overview in text presenting the learning outcomes, as well as resources, activities and unit or weekly assessments. The difference lied in the type of learning resources shared and student engagement in activities and assessments. The teachers of nine impacted blended courses shared or created multimedia-enriched resources and engaged students in active and interactive learning through forum discussions, chat interactions, interactive videos and by providing solutions to the quiz questions and creating competitive exam / a test series environment similar to the GATE (Graduate Aptitude Test in Engineering) preparation. Aravinthan and Aravinthan, 2010 examined the effectiveness of Moodle-enabled self-assessment quizzes in two Engineering courses and found a strong correlation between students who attempted the quizzes and their final grades.

On the other hand, the teachers of nine non-impacted courses failed in providing an appropriate mix of content richness, interaction, and engagement (Zhang, 2005). In the 9 non- impact blended courses, the deficiencies that resulted in negative or zero

Table 4: Blended Learning students and non-blended learning students' grades mean comparison

Blended Courses	*t*	*p* value*
Chemistry (P2S2)	3.76	0.00
Computer Organisation & Architecture	1.96	0.00
English (P2S2)	1.97	0.1
Heat Transfer Chemical Engineering	1.98	0.00
Introduction to Artificial Intelligence	1.65	0.4
Natural Language Processing	1.98	0.00
Signals & Systems	1.96	0.09
Telugu (P2S2)	1.97	0.72
Foundation Engineering	1.97	0.05
Telugu (P1S2)	2.00E+00	2E-07
Chemistry (P1S2)	1.97	0.79
Computational Fluid Dynamics	2.06	0.41
Data Mining	1.97	0.94
Design of Machine Elements II	2.00E+00	6E-07
Engineering Mathematics 1	1.96	0.00
Environmental Engineering	1.98	0.99
Heat Transfer Mechanical Engineering	1.97	0.83
Mass Transfer Operations-II	2.18	0.00

impact on students' performance include: (i) 70-80% of the learning resources were text-based files rather than multimedia, (ii) fewer activities, (iii) no moderation and interaction in the forums, (iv) no or fewer assignment submissions and quiz attempts. The number of assignment submissions and quiz attempts were 90–100% in the first month but dropped to 10–0%, as the online assessments were not considered part of evaluation, and the faculty did not grade them or provide prompt feedback. The teachers failed to engage students with online resources and activities or to motivate students to do the online assignments and provide adequate opportunity and support for student engagement through forums, thus resulted in lower proficiency and academic performance (McGee and Reis, 2012; Montgomery et al., 2015; Wichadee, 2018). As reported by the RGUKT BL teachers, they were unresponsive to students' assignment submission due to time constraints and lack of a supportive policy for including online assessments in the university's evaluation scheme.

E. Perceptions of Learning and Achievement

To derive answer to the fifth research question "How do perceptions of learning in blended courses relate to achievement?" students' perceptions about their blended learning experience with multimedia content, and online communication and interaction with faculty and students were correlated with their grades. The results indicated that there was no significant relationship between students' perceptions of learning and grades. The regression analysis with grades as the dependent variable and satisfaction construct variables as the independent variables (Table 5) indicate that the relationship between students' perception of blended learning and grades was not statistically significant, as the p values ranged between 0.21 and 0.44 and greater than the alpha (0.05) value.

Table 5: Regression analysis of student perceptions of blended learning and achievement

Student perceptions	*r*	*F*	*p*
Multimedia resources on LMS enriched my learning experience	0.31	1.72	0.21
Communicating online with students and faculty improved my learning	0.20	0.64	0.44
Blended learning improved my performance in mid-semester exams	0.30	1.57	0.23

8. Discussion and Conclusion

The intent of this study was to investigate the impact of blended learning approach on Engineering students' learning experience and effectiveness. The study examined whether blended approach improved students' satisfaction and their achievement.

Though the comparison of achievement scores of blended learning and non-blended learning students yielded mixed results, the perceptions of students were in favour of blended learning. The mixed results were due to lack of effective online facilitation for engaging students in activities and interactive learning during the course; reviewing student discussion posts and completed course assignments and providing timely instructional feedback to encourage reflection and confirm learners' understanding. While designing, developing and delivering blended courses, faculty need to become effective facilitators and e- moderators in order to establish teaching presence online and to engage students in reflective, constructive, collaborative and social learning interactions and activities for improving students' online engagement, course dedication time and performance.

The results indicated that the RGUKT blended learning environment and teachers' practices provided the students with greater convenience; efficient use of time; access to multiple learning resources; flexibility, learning at their own pace; opportunities for reflection and interactions; and a combination of synchronous and asynchronous communication.

The study concludes that the results of the study were positive in many ways and provide the needed evidence to streamline and scale up the COL-RGUKT TEL initiative to build resilient education systems during crises. One avenue of further research is to correlate faculty online facilitation and student online engagement time with their achievement.

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