International Online Journal of Education and Teaching (IOJET), Vol. 12 , No. 4, 2025 (pp. 266-280)

RESEARCH ARTICLE WWW:IoJet.org

Studying the Effects of Offline and Online Teaching on a Computer Network Course in the context of COVID-19

Supriya Kelkar[1*] Mahendra Deore[2], Meenal Kamlakar[3]

[1- 3]Department of Computer Engineering, Cummins College of Engineering for Women, Pune

Keywords:

Offline teaching,
Online teaching,
COVID-19,
Moodle,
Assessment,
Student feedback,
Evaluation.

Author's Email :
supriya.kelkar@cumminscollege.in,
Mahendra.deore@cumminscollege.in

Received : 08.06.2025
Revised : 14.09.2025
Accepted : 28.09.2025

Abstract

Contribution: This article compares traditional teaching and online teaching during COVID-19 pandemic of Computer Network course. This comparison is with respect to summative and formative assessments along with Student participation, in-class and out-class activities, attendance, feedback and different pedagogies.

Background: This Course was conducted in traditional mode during Academic Years 2018-19 and 2019-20. The Course was conducted in online mode during Academic Years 2020-21 and 2021-22 due to COVID-19 pandemic. Authors taught 597 students over these four years. Computer network course is one of the important and core courses in computer engineering. This course was offered in the first semester of the third-year computer engineering at MKSSS's Cummins College of Engineering for Women, Pune, India. During COVID-19 scenario, the teaching and learning processes shifted towards online teaching. Moving from traditional teaching to online teaching had its own challenges. These challenges are discussed in this paper.

Methodology: Outcome Based Education methodology is employed to find course outcomes using summative assessments. Statistical analysis of formative assessment is also performed.

Findings: The study period saw an increase in attendance, particularly during online classes. Student participation through discussions and question-answer sessions were marginally improved over the four academic years. There was improvement in course outcome attainment for the majority of the course outcomes. There was a significant improvement in the overall summative assessments observed over the course of four years of teaching.

How to cite this article: Kelkar S, Deore M, Kamlakar M. Studying the Effects of Offline and Online Teaching on a Computer Network Course in the context of COVID-19. International Online Journal of Education and Teaching, Vol. 12, No. 4, 2025, 266-280

Introduction

Traditional teaching involves teachers and learners using the classroom to interact with each other. Teacher's use course material and presentations to teach the learners. In traditional teaching, teachers give instructions to learners in the class itself. The classroom teaching involves teaching, discussion, question-answer session, submission of assignment etc. The traditional teaching is in the 'Physical World'. In this world there is direct interaction between teacher and learners. This helps learners to communicate with teacher in-person enabling them to acquire knowledge. It has been observed that many times learners need such human interaction to understand the course better.

Also, traditional teaching-learning requires learners and teachers to be in the same physical space or on-campus. However, Learners cannot be always on-campus to pursue their education due to various reasons such as, duration of the course, on-campus time to be committed and unaffordable on-campus fees, etc. Due to an increase in the number of online learners, online enrollments are growing.[1]

In such scenarios, universities and colleges were required to be innovative and provide better options to the learners so that learners could pursue their education even being off campus. Off-campus learning or distance learning was the reason universities offer online courses.

Earlier, universities and colleges offered online courses through Information and Communication technology (ICT). Learners would register to these courses by paying affordable fees and thereby getting access to the learning resources. These online courses use resources such as presentations and videos to teach the course. During the course, the learners were evaluated through quizzes, tests, projects, etc. Instructors made use of effective online learning pedagogy tool such as Moodle to transfer their curriculum in the form of online content.[2] Massive Open Online Courses (MOOCs) are the best example where the online courses are offered for free.

On-campus traditional classroom teaching was affected due to COVID-19 pandemic. There was a restriction on in-person gathering. This scenario forced the universities and colleges to change the method of delivery of courses which otherwise would have followed the traditional approach. Researchers have suggested various strategies for teaching courses in online mode.[3-5] Also there is a discussion on aspects such as time required for online teaching, stakeholder's perceptions, and motivation of online learners.[1, 5, 6]

In this paper, authors present their experience while teaching Computer Networks course in the third year computer engineering at undergraduate level for four years, namely, academic year (A.Y.) 2018-19, A.Y. 2019-20, A.Y. 2020-21and A.Y. 2021-22.

For the first two years, authors used traditional teaching learning methodology which involved in-person teaching for conducting lectures and tutorials. During the first two years of teaching, authors also used: 1) Revision questions at the beginning of every lecture to refresh concepts learnt in the earlier lecture, 2) Tutorials to strengthen the concepts taught in the lectures through problem solving 3) Quizzes during the tutorial to evaluate the concepts learnt, 4) Flipped classroom in-class and out-class activities and 5) Think-Pair-Share activities.

However, in the last two years viz. A.Y. 2020-21 and A.Y. 2021- 22, authors used online mode exclusively to teach the same course due to the COVID-19 pandemic. During these years of teaching, authors used the Learning Management System (LMS), namely, gnomio Moodle to teach the course.

In this article, authors share their experience of online and in-person teaching of computer networks courses by focusing on student performance, student engagement and student feedback.

The remainder of the article is structured as follows. Section II presents previous work from related domains and beyond. Section III provides overview of the course conduction online and in-person teaching along with the results and observations in detail. Section IV presents the conclusion.

Literature Review

Flipped classroom approach was used by Lucas Green [7] for improving student enrolment and grades while teaching empirical software engineering course. Author found that students rated flipped classroom approaches better than conventional classroom teaching. Author concludes that there should be

relevance between online and in-class study material along with teachers to have rigorous training and a new skill set.

A mixed teaching Pedagogy using PBL, Inquiry-based learning and kinaesthetic learning was used to prepare a new framework to provide a cloud-based teaching learning experience to students by the authors.[8] Cloud Mode and on campus mode was used to offer courses by the authors for improving student engagement and motivation of student learning in cloud mode. It was observed that such mixed pedagogy usage enhances the learning in online mode.

Demaidi et al.[9] used a blended learning approach for teaching C language to undergraduate students. Traditional learning with technology and online learning was used for one group of students whereas the other group was taught using only traditional learning methods. Authors found blended learning approach was better than the traditional learning approach w.r.t. student's performance, satisfaction and ease of use.

Sasidhar et al.[10] incorporated live weekly revision sessions to enhance the interest in learning power system courses for engineering students. This approach used a framework involving blended learning, live teaching, and recorded videos. Student's perception survey was used to analyze the efficiency of the methodology qualitatively and quantitatively. It was seen that the weekly live revisions were majorly helpful.

Authors[11] present their efforts of the improved learning approach using collaborative learning techniques while teaching geometry to primary school children. The feedback was collected to find students' opinions on using several platforms to learn geometry. Also, the level of student satisfaction was collected through the pair learning method. Majority of students were satisfied when collaborative learning was used.

While teaching power system course, author used e-assignments and peer review to enhance critical thinking.[12] An extensive rubric was used to assess the assignments with plagiarism checks. Latest topic in energy power systems was given. Majority of the students found the topic relevant, and the assignment helped the students to understand the topic better.

A blended learning approach was used by Andersen et al.[13] for students of UG and Graduate Computer Engineering programs. Students underwent traditional teaching along with exploring web content and to find suitability of the contents for the course. Specific observations were made by students in web content. Authors aimed at making students critical users of web contents. They found the students of current generation are more comfortable in using internet resources than the older generation. Students used the web resources very well to their advantage with respect to their course.

Moodle is one of the learning platforms used by teachers. Sasidhar et al.[14] analyzes the data collected through questionnaires filled by the lecturers of the 5 different faculties of their university. They found that there was a limited use of Moodle made by lecturers for sharing of learning material, to make announcements and to perform automated tasks which do not require teachers' interventions, etc. Majority of lecturers were found to have skill at the beginner's level for using the Moodle platform. The level of usage of Moodle depends upon the teaching experience of lecturers, their Moodle experience and the training course they completed.

Authors[15] conducted a digital logic design course at UG computer engineering program which was free of lectures. Role of the teacher was that of a facilitator. Students completed the course where lecture time was used for completing learning activities. Students were more engaged in the classroom and they could work at their own pace. The result showed improvement in student performance in the final examination. Around 50 % of the students found the learning activities interesting and also students evaluated the course positively.

Gamification was used in the online discussion environment of Moodle to evaluate the students' engagement[16] during their term projects. Different Moodle plugins were considered to gamify the discussion environment. Students were able to move to the next level in the project module by earning specific experience points. The gamification was through an engagement environment, collecting points required and thus allowing students to move to the next level for completing their term project. Leader board was used to encourage the students

to improve their performance. Authors found that contribution to the gamified Moodle environment was done by the students as they were motivated to use the same.

The paper[17] considered LMS data of student's taking17 courses for predicting student performance. Authors used prediction model to predict student performance in terms of final exam grades and pass-fail probabilities per course. It was observed that the prediction model could not be ported across the courses. Also, it was seen that the final grade of the student depends upon his/her efforts and characteristics, behavior of the students and time spent on the LMS. It was concluded that better to analyze LMS data of courses separately rather than combining or aggregating the LMS data of all courses.

The problems[18] observed by students and teachers while using the Online Judge System (OJS) for C programming were addressed by the authors. Locating logical errors was addressed using fault localization technique. Cheating by forging the answers was detected using control and data flow analysis on the assembly form of the C code. Also authors made the method to submit the code convenient thus making the OJS more acceptable.

Approach to improve teaching[19] an introductory course in digital systems was proposed by the author. The obstacles faced while using student centric teaching methods were observed by the author. Strategies to improve student centered learning were proposed in this paper. Student attendance and grades in final examinations over a few years were used to make few conclusions. Statistical analysis of student attendance rate and student grades was performed to draw conclusions such as improved student attendance and student performance in final exams. Competitive and collaborative teaching learning strategy was used by authors[20] to teach communication networks course. Tools such as Moodle wiki and competitive learning tool QUESTOURnament were utilized for this purpose. Out of 3 years, the new methodology was applied for the last 2 years and student's academic outcome and feedback were analyzed. It was observed that there was improvement in academic results and passing of students along with good student opinion. Comparison of literature based on various aspect of teaching learning used by different authors is shown in Table 1.

Table 1: Comparison of literature based on various aspects

Sr. No.	Author Year	Teaching Approach			Addressed Aspect / Parameters			Methodologies Used		Unit	
		Active	Flipped Classroom	Mix/ Blended Pedagogy	Student Performance	Student Attendance	Attention Span	Predictive Analysis	Statistical Method	Course/ Evaluation Feedback	Faculty Survey Feedback
1	Gren et.al 2022[7]		☑		☑				☑	☑	
2	Asma et.al[8]			☑					☑	☑	
3	Demaidi et.al 2019[9]			☑	☑				☑	☑	
4	Sasidhar et.al 2019[10]			☑		☑			☑	☑	
5	Echeverría et.al 2019[11]			☑	☑				☑	☑	
6	Sasidhar et.al 2019[12]			☑						☑	
7	Andersen et.al 2018[13]										
8	Esnaola et.al 2020[14]			☑					☑		☑
9	Shoufan et.al 2020[15]	☑			☑				☑	☑	
10	Hasan et.al 2019[16]	☑			☑				☑		

Sr. No.	Author Year	Teaching Approach			Addressed Aspect / Parameters			Methodologies Used		Unit	
		Active	Flipped Classroom	Mix/ Blended Pedagogy	Student Performance	Student Attendance	Attention Span	Predictive Analysis	Statistical Method	Course/ Evaluation Feedback	Faculty Survey Feedback
11	Conijn et.al 2017[17]			☑	☑			☑	☑		
12	XiaohongSu et.al 2016[18]	☑									
13	D□biec et.al 2018[19]			☑	☑	☑			☑	☑	
14	Regueras et.al 2011[20]			☑	☑				☑	☑	
15	Yilmaz et.al 2011[21]			☑					☑	☑	
16	Trenas et.al 2011[22]			☑					☑	☑	
17	Ghazal et.al 2018[23]										
18	Kothiyal et.al 2018 [24]	☑	☑		☑				☑		☑
19	Wallace et.al 2013[25]	☑	☑						☑	☑	
20	Jasmine et.al [26]	☑	☑		☑				☑		

In this paper Authors consider teaching learning methodology while teaching Computer Networks Course at Third Year Computer Engineering for undergraduate program in Autonomous Institute MKSSS's Cummins College of engineering for Women, Pune. This Teaching Methodology Involves First two years of Conventional classroom based teaching and two years of online teaching along with the use of LMS such as Moodle. This Paper compares student performance throughout the semester and at the end of semester with respect to conventional and online teaching. Student attendance and performance in activities are compared. This work has been validated using academic outcomes and students feedback.

Course Implementation

The Engineering Institute, to which author's belong, follows the Outcome Based Education (OBE) approach. OBE intends to orient the education system to be student-centric and focuses on what students will be able to do at the end of the course or program. Thus, the teacher has to play not only the role of an instructor but also as facilitator and mentor. Thus, authors have adopted the OBE approach while teaching CN course. Course was designed by referring various sources and also ACM Computer Engineering Curricula 2016 guidelines.[27]

CN course was designed as per the Course Outcomes (COs). The revised Bloom's Taxonomy (BLT) was referred while defining Course Outcomes (COs) for the CN course. BLT defines 6levelsofcognitivelearning, namely, 1) remember, 2) Understand, 3) apply, 4) analyze, 5) evaluate and 6) create [28]. Authors decided to set the COs for CN course at BLT levels either at 3 or 4. The course addresses the upper three layers of TCP-IP protocol suite and recent trends and technologies in computer networks. Students are expected to learn various protocols/ algorithms at each layer and data flow between two entities w. r. t. TCP-IP.

The following are the COs defined for CN course:

a) *Apply and distinguish the fundamental concepts of networking standards, protocols and technologies.(BLT 3)*
b) *Identify the role of protocols at various layers in the protocol stack. (BLT3)*

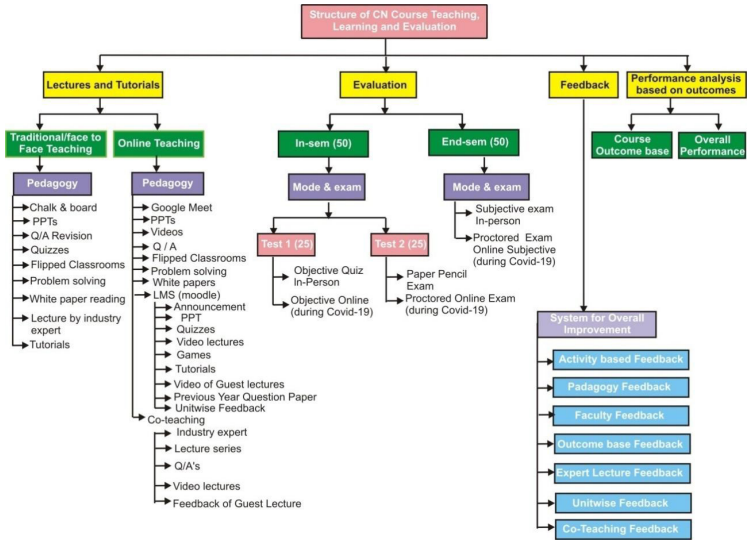


Fig-1: CN Course Structure -Teaching, learning and Evaluation

c) *Select and Compare the appropriate network by understanding the given requirements for a given system.(BLT4)*

d) *Identify fundamental concepts of wireless network, mobile network and network security.(BLT 3)*

The teaching scheme consists of three hours of lectures per week along with one hour tutorial per batch where each class was divided into 4 batches. Number of credits allocated to the CN course was 4.

Architectural diagram Fig. 1 of the CN course depicts:

A. Lectures and Tutorials
B. Evaluation
C. Feedback
D. Performance Analysis

A. Lectures and Tutorials

Course was delivered in two ways, one using traditional/face to face teaching and second using online teaching methods. Course was taught using traditional teaching methodology during A.Y. 2018-19, A.Y. 2019-20 and using online teaching methodology during A.Y. 2020-21, A.Y. 2021-22. Authors taught one class each of the said A.Y.s. Total number of students taught in the above said A.Y.s were, 136,155,148 and 158 respectively.

1) *Traditional / face to face teaching:* The CN course was delivered using traditional teaching methodologies. Every lecture was conducted using chalk and board, PowerPoint presentations. These lectures were interactive in nature where students were encouraged to ask questions and have discussions on the topic or concept. At the beginning of every lecture, authors asked questions to revise the earlier lecture's learning. Authors presented learning objectives at the beginning of every lecture and concluded the lecture with a discussion on how the learning objectives were met. Also indicating how meeting these learning objectives were contributing to a specific CO. Students were provided with textbook references, web references and Power Point presentations.

Objective of the tutorials was to strengthen the concepts learnt in the lectures through problem solving. Set of problems were solved weekly based on the concepts of algorithms learnt using the paper pencil method. Students were given challenging problems if they solved easier problems. Authors helped students who could not solve easier problems. During the tutorials, quizzes and problem solving were conducted by the authors to evaluate the students' learning. Except for the A.Y. 2018-19, the tutorials were non-evaluatory in nature, which meant the evaluation of the tutorials did not contribute to the total marks obtained by the student for the CN course.

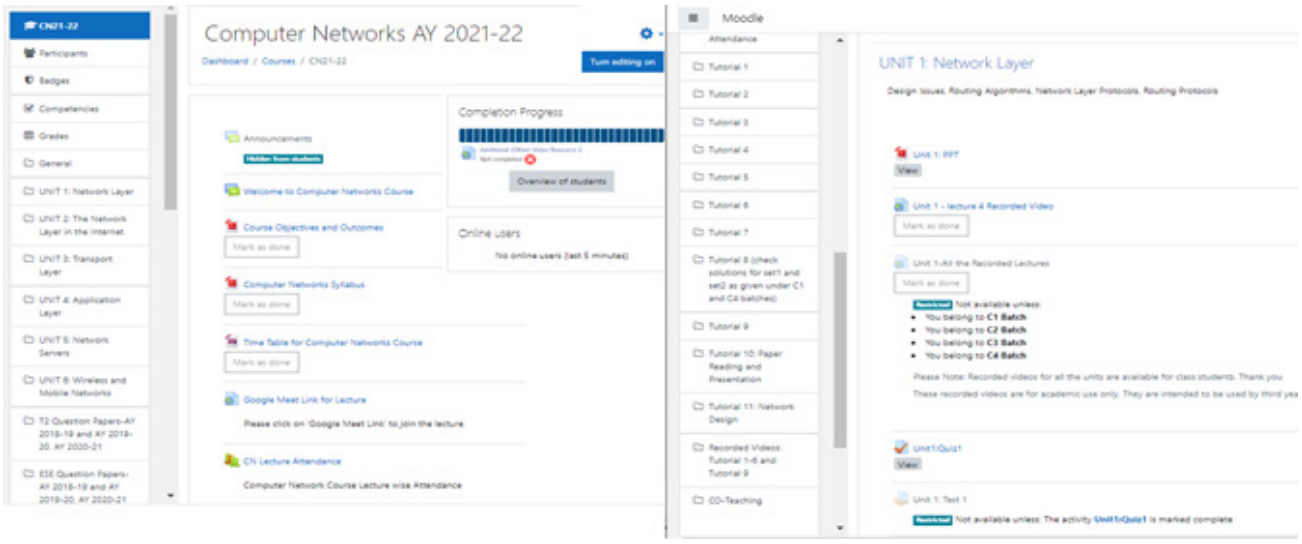


Fig. 2: LMS Gnomio Moodle-Instructor's View

2) *Online teaching:* The CN course was delivered through the online platforms during A.Y. 2020-21 and A.Y. 2021-22 in the context of COVID-19 pandemic. To deliver the course, authors made use of Learning Management System (LMS), namely, Gnomio Moodle and Google Meet. Gnomio Moodle provides hosting the Moodle service at free of cost. During this period, the world was severely affected by COVID-19 pandemic. Authors were challenged to conduct the course in the online mode instead of using good old traditional teaching methods. Authors took it upon themselves to learn more about the Gnomio Moodle platform after going through a basic training at their institute.

The objective of using Gnomio Moodle for CN course was to 1) provide all the required resources to students for learning the course 2) provide teaching learning activities such as quizzes, games and crossword puzzles, etc. 3) collect feedback from students about teaching learning 4) record theattendance5) Make announcements 6) encourage students to participate in discussion forums. Thus, a seamless access for teaching and learning resources and communicating with students was made easy using Gnomio Moodle platform [29].Google Meet was used to conduct lectures. These lectures were recorded and shared with students on Moodle for revision purposes. The following Figure 2 depicts the CN Moodle site designed by the authors. The figure shows topic and activities made available for students on CN Moodle site.

3) *Analysis of traditional v/s online teaching-learning:* During traditional teaching of the course, the quizzes and problem solving were conducted as part of the tutorials and were evaluated for A.Y. 2018-19. For the other three years, the activities such as quizzes, problem solving was completed by the students voluntarily as part of the tutorials which were non evaluatory nature. Number of students completing these activities was reduced when completed voluntarily by the students as shown in Fig. 3. Fig 3 shows the percentage of students completing activities for A.Y. 2018-19, A.Y. 2019- 20 in offline mode and for A.Y. 2020-21, A.Y. 2021-22 in online mode. The average percentage of students for A.Y. 2018-19, A.Y. 2019- 20, A.Y. 2020-21 and A.Y. 2021-22 are 92.66%, 83.52%, 71.17% and 63.73% respectively.

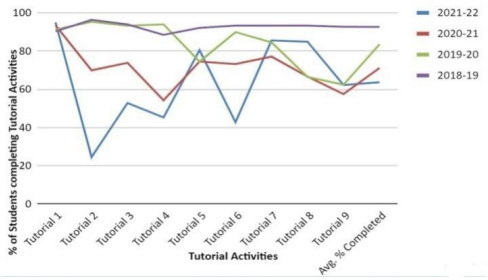


Fig. 3: Tutorial Activity Completion

Authors observed that more than 80% of the students were found attentive in the traditional (face-2-face) classroom. Also, around 5% of the students asked questions during the traditional classroom teaching. However, during online teaching, it was difficult to check the attentiveness of the students as the cameras were not switched on by the students even after requests made by the instructors. The reasons such as internet bandwidth issues faced by the students and students' reluctance to switch on the camera were noticed. There was a slight increase in the students asking questions during online teaching was found to be 8% as compared to 5% in case of offline teaching. Authors conclude that this slight increase was due to students not experiencing inhibition to express their views as they were not on camera or in person.

During online teaching of the course, namely for the A.Y. 2020-21 and A.Y. 2021-22, authors set up quizzes for important teaching modules (units) and tutorials. The whisker plot in Fig. 4 shows the assessment distribution for the same. There is a significant improvement for the A.Y. 2021-22 over A.Y. 2020-21 considering the key values such as mean, median, lower quartile and upper quartile for Unit 1, Unit 2, Unit 4 and tutorial 8. This indicates the improved performance in the quizzes. However, there is a decreased performance of the students in tutorial 1 quiz for A.Y. 2021-22 as compared to A.Y. 2020-21.

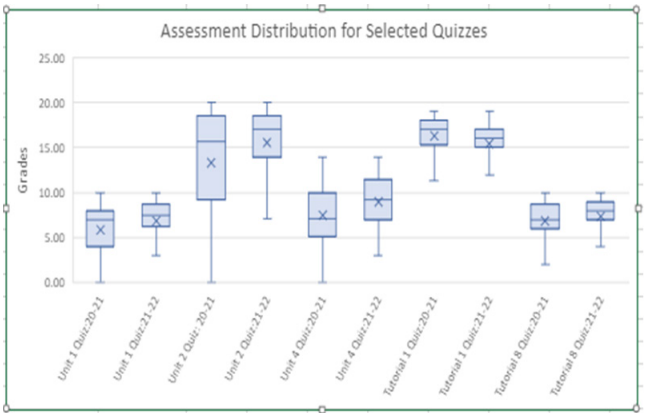


Fig. 4: Formative Assessment Distribution for Selected Quizzes

The distribution is negatively skewed for both the years in case of Unit 1, Unit 2 quizzes. The marks obtained by students found to be less dispersed in case of Unit1, tutorial 1and tutorial 8 for A.Y. 2021-22.

Quizzes and tutorials were used as tools for formative assessment. The evaluation of students' performance through these tools was utilized to understand students' learning of the topic or unit of the course. Thus it was useful for the instructor in improving or modifying the teaching learning process during the course of the teaching.

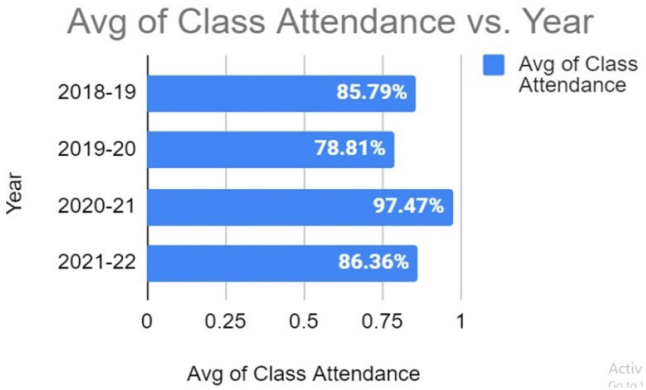


Fig. 5: Average Attendance during Academic Years

Fig. 5 indicates the average class attendance for the four years where, A.Y's. 2018-19 and 2019-20 being traditional classes and A.Ys. 2020-21 and 2021-22 being online classes. It was found that more students attended the online lectures as compared to the offline/face-to-face lectures. It was more convenient for the students to attend the classes as they were joining online classes from their locations or homes.

B. Evaluation:

It is summative assessment made up of two examination, namely In-Semester and End-Semester examinations, each consisting of 50 marks. In-semester examination consists of two tests, Test1 (T1) and Test2 (T2). Both, T1 and T2 are evaluated for 25 marks each. Mode for T1 can be subjective or objective in nature. It can also be conducted using other modes such as presentations, technical paper presentation, etc. T2 and end-semester examinations are conducted using a paper-pencil method. During Covid-19 scenario, these examinations were proctored in nature. Questions asked in examinations were mapped to course outcomes so that the COs

could be measured. The course assessment plan was prepared by the instructors as shown in Table 2. This plan depicts the course contents in the form of units and their weightage in T1, T2 and end-semester examination. This plan also shows the mapping of units with respect to COs and BLTs.

Table 2: Course Assessment Plan

Unit-wise Marks		Examination-wise-CO1			Examination-wise-CO2			Examination-wise-CO3			Examination-wise-CO4			Revised Bloom's Level (BLTs)
		T1	T2	ESE	T1	T2	ESE	T1	T2	ESE	T1	T2	ESE	
I	16	12		4										L3,L4
II	18	6						7		5				L3,L4
III	23		9			6	8							L3,L4
IV	13		6	3		4								L3
V	14			4						10				L3,L4
VI	16						4						12	L3
Total	**100**	**44**			**22**			**22**			**12**			

C. Feedback:

Overall improvement in teaching and learning is brought about by collecting feedback on the various aspects of teaching-learning. Feedback on overall faculty teaching and course outcomes were collected by the institute and the department respectively. Similarly, feedback on unit-wise teaching, expert Lectures and Co-teaching collected by the instructors. These were measured based on a 4 point or a 5 point Likert scale. During the online teaching of the course, instructors conducted various activities to encourage students to participate in learning. Tasks such as unit wise quizzes, games (crossword, millionaire) were given to the students to complete and their responses were recorded.

Various pedagogies such as, quizzes, flipped classroom, games, Think-Pair-Share, co-teaching, etc. were used by the instructors during the course. The feedback for the same was recorded.

Department also collects the feedback of the Instructor from the students. This feedback is based on teaching methodology, technical contents and subject expertise, communication skills, behavior towards students, punctuality, etc. The feedback is also collected for the expert lectures con- ducted by the industry experts. For A.Y. 2021-22, instructors also used co-teaching pedagogy. The industry expert was part of this activity.

Feedback for the same was collected from the students. Also, course outcome based feedback was collected from the students to understand their perception of understanding the course.

The following questions were asked by the instructors at the end of teaching learning of every unit.

Feedback Analysis during A.Y.2021-22

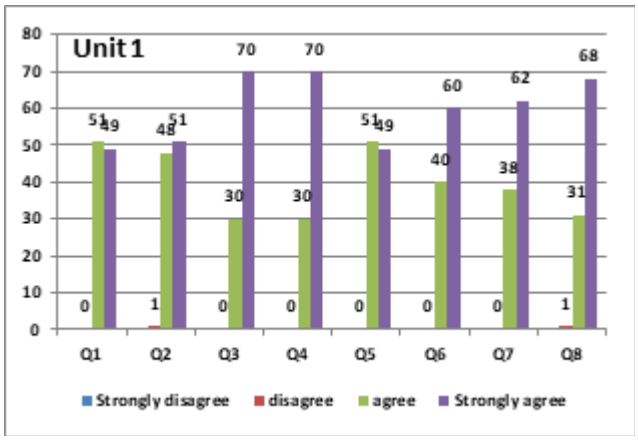
Q.1 The information in the Unit 1 was understandable.
Q.2 The contents of presentation for Unit 1 are helpful.
Q.3 The instructor demonstrated knowledge of the subject.
Q.4 The instructor appeared enthusiastic and interested.
Q.5 The 'CN Moodle platform' is useful in learning Computer Network course.
Q.6 The activities such as Quiz, Crossword, Millionaire game, etc. found on 'CN Moodle platform' are helpful to evaluate what I have learned.
Q.7 Revision of the earlier taught topics, taken by the instructor are helpful.
Q.8 Activities such as polls and attention check, conducted by the instructor are interesting.
Q.9 Rate the experience of this teaching method.

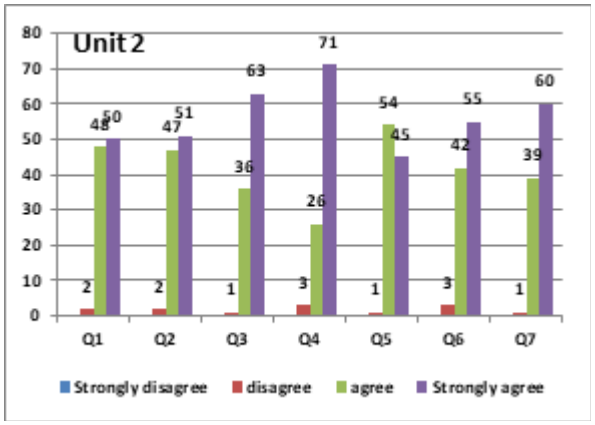
Questions 1 to 4 were about the instructor's teaching skills and knowledge and questions 5 to 8 were about the various pedagogies used during teaching-learning. Instructors also collected feedback on teaching methods used during online mode. The Fig.6 depicts this feedback for A.Y. 2021-22.

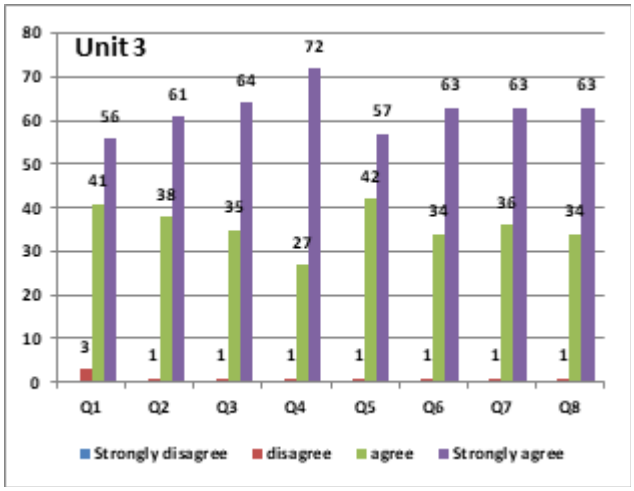
More than 97 percent of the students appreciated the in- structure's knowledge, and teaching skills along with strong affirmation of understanding the course. The pedagogies used by the instructors were enjoyed and well appreciated by more than 98 percent of the students. 99 percent of the students responded positively towards the teaching methods used by the instructors.

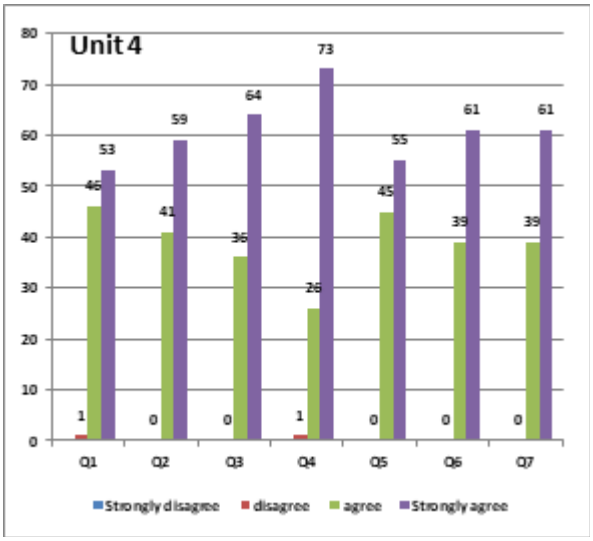
D) Performance Analysis:

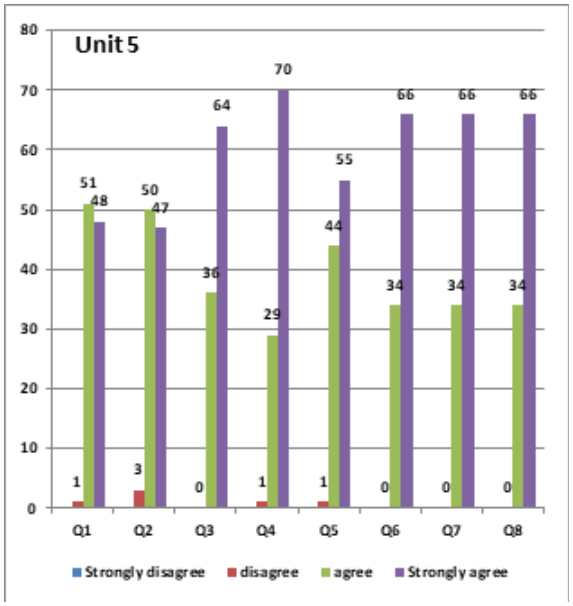
Performance analysis evaluated based on Cos and overall performance of the students.











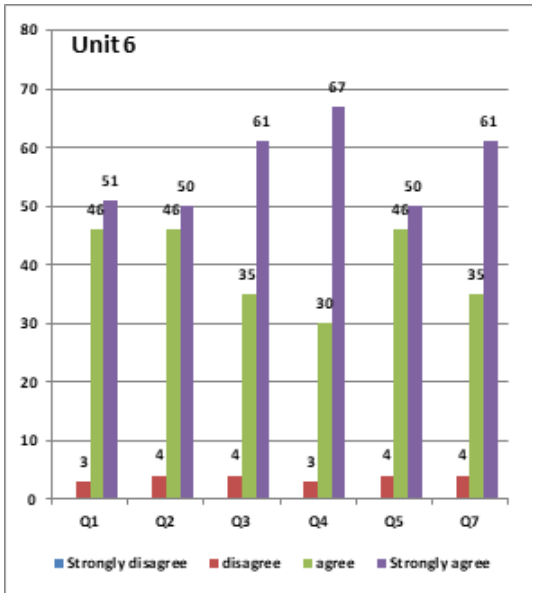


Fig. 6a: Feedback Analysis during A.Y.2021-22

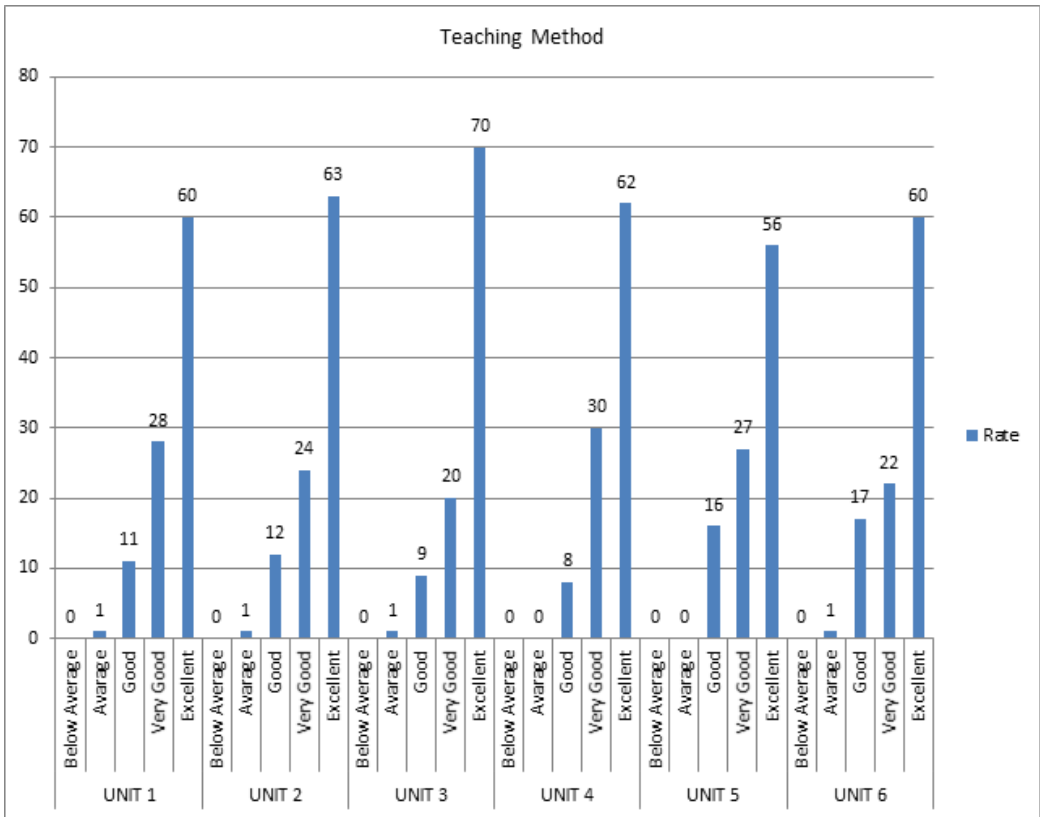


Fig. 6b: Feedback Analysis during A.Y.2021-22

1) Performance Analysis based on COs Students' performance was measured as per COs for T1, T2 and ESE examination. The CO attainment was calculated based on this performance and the CO based feedback. The CO attainment consists of two types of attainments, direct and i ndirect.

Direct and Indirect Attainments: Direct attainment is calculated based on student performance in ISE (T1and T2) and ESE. There are two important parameters which decide whether a given CO has been attained or not, namely target and benchmark. Target is about the percentage of students scoring marks whereas benchmark is about percentage of marks. Co attainment can be of level 1 or level 2 or level 3shown in Table 3. A given CO is attained if and only if level 3 is achieved, i.e.: If More than 59% students (Target) scoring marks equal to or greater than the Benchmark value (60%).

Table 3: Course Outcome Levels

Level 1	Less than 40% students (Target) scoring marks equal to or greater than the Benchmark value (60%)
Level 2	More than 39% and less than 60% students (Target) scoring marks equal to or greater than the Benchmark value (60%)
Level 3	More than 59% students (Target) scoring marks equal to or greater than the Bench-mark value (60%)

Table 4 shows the CO attainment for A. Y's. 2018-19, 2019-20, 2020-21 and 2021-22.Indirect attainment is based on CO based feedback. This feedback is given by the students about the knowledge gained in the course. Therefore,

Total attainment of a given CO Attainment for ISE/ESE

= (95% of ISE/ESE) + (5% of Course outcome feedback)

Table 4: course outcome attainment

			ISE Attainment				ESE Attainment				
			Benchmark = 60%				Benchmark = 60%				
Year	No. of Students		% of Students above Benchmark	Direct	Indirect	Total	% of Students above Benchmark	Direct	Indirect	Total	Total Attainment
2018-19	163	CO1	86.31	3	2.17	2.96	73.81	3	2.17	2.96	2.57
		CO2	61.31	3	2.19	2.96	68.45	3	2.19	2.96	2.58
		CO3	91.67	3	2.21	2.96	47.62	2	2.21	2.01	2.11
		CO4	NA	NA	NA	NA	67.86	3	2.1	2.96	2.53
2019-20	155	CO1	97.42	3	2.47	2.97	68.39	3	2.47	2.97	2.97
		CO2	92.26	3	2.48	2.97	47.75	3	2.48	2.97	2.97
		CO3	50.32	2	2.44	2.02	62.61	3	2.44	2.97	2.5
		CO4	NA	NA	NA	NA	67.1	3	2.38	2.97	2.97
2020-21	148	CO1	95.95	3	2.56	2.98	81.08	3	2.56	2.98	2.98
		CO2	77.03	3	2.76	2.99	65.54	3	2.76	2.99	2.99
		CO3	29.05	1	2.6	1.08	65.54	3	2.6	2.98	2.03
		CO4	NA	NA	NA	NA	72.97	3	2.62	2.98	2.98
2021-22	158	CO1	89.69	3	2.43	2.97	74.13	3	2.43	2.97	2.97
		CO2	69.52	3	2.38	2.96	55.6	2	2.38	2.01	2.35
		CO3	80.68	3	2.54	2.97	75.43	3	2.54	2.97	2.97
		CO4	NA	NA	NA	NA	81.46	3	2.41	2.97	2.97

Based on the past performance of the students and the difficulty level of the course, the target level for each course is decided. It is increased only when the target level is achieved for consecutive two years. Once the highest level is attained then either the benchmark or target of the level is increased. For AY 2018-19, 2019-20 and 2020-21, CO1, CO2 and CO4 were attained.

However, CO3 was not attained. It was observed that CO3 was about selecting and comparing appropriate networks by understanding the requirements for a given system. Thus, CO3 was about designing networks and selecting appropriate addressing schemes. Students found difficulty in solving such problems. Some of the actions taken to improve the attainment of CO3 were, 1) Variety of problems solved in-class 2)Extra tutorial session was added to give more practice 3) Recorded lectures of the instructors were shared with students specially for solved problems.

With these efforts, during A.Y. 2021-22, CO3 was attained. However, during A.Y. 2021-22, CO1, CO3 and CO4 were attained but CO2 was not attained, as shown in Table 5. The action was planned to improve CO2attainment.

Table 5.: Year-wise CO Attainment

	2018-19	2019-20	2020-21	2021-22
CO1	Attained	Attained	Attained	Attained
CO2	Attained	Attained	Attained	Not Attained
CO3	Not Attained	Not Attained	Not Attained	Attained
CO4	Attained	Attained	Attained	Attained

2) Overall Performance Analysis:

As seen in the Table 6 for summative assessment, there is a visible improvement in the percentage of marks for the highest range during A.Y. 2020-21 and 2021-22. There is a reduction in percentage of marks for the highest range during A.Y. 2018-19 and 2019-20 which involved traditional teaching. During A.Y. 2020-21 and A.Y. 2021-22, the course was conducted in the on line mode due to pandemic. However, the mode of examinations remained the same for traditional and online.

Table 6: Summative assessment Year wise % of students for different ranges of marks

Academic Year	% of Students in >40 and <50	% of Students >49 and <80	% of Students >79 and <100
18-19	8.60%	63.33%	19%
19-20	1.93%	59.43%	16.1%
20-21	3.37%	58.1%	38.5%
21-22	5%	42.4%	52.5%

However, online examinations were proctored in A.Y. 2020-21 and 2021-22. Instructors used many pedagogy and LMS for teaching and learning for these years. It is also seen that the percentage of students getting marks less than 80% and greater than 49% during A.Y. 2018-19 and 2019-20 is higher as compared to the percentage of students in the same range for AY 2020-21 and 2021-22. This is due to an increase in the percentage of students getting marks greater than 79% and less than 100% during AY 2020-21 and AY 2021-22. It is clearly observed that there is a positive impact of usage of pedagogies and round the clock availability of learning resources through LMS on the results of the students during the years 2020-21 and 2021-22.

The percentage of students getting marks greater than 40 % and less than 49 % has been unpredictable and variable during all the four academic years. This may be due to the varying efforts put-in by the slow learners and their acceptance of various pedagogies used by the instructors.

Conclusion

This work presents traditional versus online teaching of the Computer Network course with respect to various aspects such as attendance of the students, attentiveness of the students in class, performance in tutorials, quizzes, feedback, course outcome based attainment and overall performance in the examinations over the four years of teaching. Performance was measured using various performance metrics such as summative assessments namely T1, T2 and ESE examination. Along with summative assessments, formative assessments such as students' performance in tutorials, quizzes and unit wise/ based feedback, revision questions at the beginning of every lecture, etc. were used to improve teaching-learning during the course.

Instructors faced challenges to attain CO3 for the first three years. There were lot of efforts made by the instructors to attain CO3 using different pedagogies and improved methodology for problem solving. It was also observed that student performance has increased substantially during the A.Y. 2020-21 and 2021-22 Inspite of COVID-19 Pandemic.

There were challenges faced by instructors while teaching in both the modes. The external contributing factors such as quality of students, their attitude towards learning, other commitments or activities undertaken by students, time management also played a role in student's performance. Navigating these challenges and making students learn a core course such as Computer Networks was very satisfactory.

References

1. Rebecca Van de Vord and Korolyn Pogue Washington State University, USA, "Teaching Time Investment: Does Online Really Take More Time than Face-to-Face?," The International Review of Research in Open and Distance Learning
2. Knutzen, B and Kennedy, D.M. (2008) *Can Learning to Use Moodle Alter Teachers' Approaches to Teaching?* In: World Conference on Educational Multimedia, Hypermedia and Telecommunications (2008), Chesapeake, VA, USA.
3. D. Yang, "Instructional strategies for teaching science online," 2013 IEEE Frontiers in Education Conference (FIE), 2013, pp. 1477-1479, doi: 10.1109/FIE.2013.6685081.
4. Darius, P.S.H., Gundabattini, E. & Solomon, D.G. A Survey on the Effectiveness of Online Teaching-Learning Methods for University and College

Students. *J. Inst. Eng. India Ser. B* 102, 1325–1334 (2021). https://doi.org/10.1007/s40031-021-00581-x

5. Lokanath Mishra, Tushar Gupta, Abha Shree, Online teaching-learning in higher education during lockdown period of COVID-19 pandemic, International Journal of Educational Research Open, Volume1,2020,100012,ISSN26663740,https://doi.org/10.1016/j.ijedro.2020.100012.
6. Romualdas K. Malinauskas, JuratePozeriene, 'Academic Motivation Among Traditional and Online University Students', European Journal of Contemporary Education E-ISSN 2305-6746, 2020, 9(3): 584-591 DOI: 10.13187/ejced.2020.3.584
7. L. Gren, "A Flipped Classroom Approach to Teaching Empirical Software Engineering," in *IEEE Transactions on Education*, vol. 63, no. 3, pp. 155-163, Aug. 2020, doi: 10.1109/TE.2019.2960264.
8. Aziz, Asma & Islam, Shama. (2021). Impact of Mixed Pedagogy on Engineering Education. IEEE Transactions on Education. PP. 1-8. 10.1109/TE.2021.3088808.
9. M. N. Demaidi, M. Qamhieh and A. Afeefi, "Applying Blended Learning in Programming Courses," in *IEEE Access*, vol. 7, pp. 156824-156833, 2019, doi: 10.1109/ACCESS.2019.2949927.
10. S. Sasidhar, "Weekly Live Revision Sessions to Scaffold Student Learning in a Blended Learning Course," *2019 IEEE Frontiers in Education Conference (FIE)*, 2019, pp. 1-5, doi: 10.1109/FIE43999.2019.9028715.
11. L. Echeverría, R. Cobos and M. Morales, "Improving the Students Computational Thinking Skills With Collaborative Learning Techniques," in *IEEE Revistalberoamericana de Tecnologias del Aprendizaje*, vol. 14, no. 4, pp. 196-206, Nov. 2019, doi: 10.1109/RITA.2019.2952299.
12. S. Sasidhar, "Enhancing Critical Thinking in Engineering by Incorporating an E-assignment and Peer Review in a Blended Learning Course," 2019 IEEE Frontiers in Education Conference (FIE), 2019, pp. 1-5, doi: 10.1109/FIE43999.2019.9028622.
13. K. Andersen, G. Geirsdottir, S. E. Thorsteinsson, H. Thorbergsson and K. S. Gudmundsson, "Engineering Education Case Studies: Engaging Students in Blended Learning," 2018 IEEE International Professional Communication Conference (ProComm), 2018, pp. 203-206, doi: 10.1109/ProComm.2018.00047.
14. I. Esnaola-Arribillaga and M. J. Bezanilla, "Levels of Moodle Use to Support University Face-to-Face Teaching," in IEEE Revistalberoamericana de Tecnologías del Aprendizaje, vol. 15, no. 3, pp. 129-137, Aug. 2020, doi: 10.1109/RITA.2020.3008376.
15. A. Shoufan, "Lecture-Free Classroom: Fully Active Learning on Moodle," in IEEE Transactions on Education, vol. 63, no. 4, pp. 314-321, Nov. 2020, doi: 10.1109/TE.2020.2989921.
16. H. F. Hasan, M. Nat and V. Z. Vanduhe, "Gamified Collaborative Environment in Moodle," in IEEE Access, vol. 7, pp. 89833-89844, 2019, doi: 10.1109/ACCESS.2019.2926622.
17. R. Conijn, C. Snijders, A. Kleingeld and U. Matzat, "Predicting Student Performance from LMS Data: A Comparison of 17 Blended Courses Using Moodle LMS," in IEEE Transactions on Learning Technologies, vol. 10, no. 1, pp. 17-29, 1 Jan.-March 2017, doi: 10.1109/TLT.2016.2616312.
18. XiaohongSu, Jing Qiu, Tiantian Wang and Lingling Zhao, "Optimization and improvements of a Moodle-Based online learning system for C programming," 2016 IEEE Frontiers in Education Conference (FIE), 2016, pp. 1-8, doi: 10.1109/FIE.2016.7757699.
19. P. Dębiec, "Effective Learner-Centered Approach for Teaching an Introductory Digital Systems Course," in IEEE Transactions on Education, vol. 61, no. 1, pp. 38-45, Feb. 2018, doi: 10.1109/TE.2017.2729498.
20. L. M. Regueras, E. Verdú, M. J. Verdú and J. P. de Castro, "Design of a Competitive and Collaborative Learning Strategy in a Communication Networks Course," in IEEE Transactions on Education, vol. 54, no. 2, pp. 302-307, May 2011, doi: 10.1109/TE.2010.2053933.
21. Ö. Yilmaz and K. Tunçalp, «A Mixed Learning Approach in Mechatronics Education,» in IEEE Transactions on Education, vol. 54, no. 2, pp. 294-301, May 2011, doi: 10.1109/TE.2010.2053932.
22. M. A. Trenas, J. Ramos, E. D. Gutierrez, S. Romero and F. Corbera, "Use of a New Moodle Module for Improving the Teaching of a Basic Course on Computer Architecture," in IEEE Transactions on

Education, vol. 54, no. 2, pp. 222-228, May 2011, doi: 10.1109/TE.2010.2048570.

23. S. Ghazal, H. Al-Samarraie and H. Aldowah, ""I am Still Learning": Modeling LMS Critical Success Factors for Promoting Students' Experience and Satisfaction in a Blended Learning Environment," in IEEE Access, vol. 6, pp. 77179-77201, 2018, doi: 10.1109/ACCESS.2018.2879677.
24. Kothiyal, A., Majumdar, R., Murthy, S., &Iyer, S.V. (2013). Effect of think-pair-share in a large CS1 class: 83% sustained engagement. *Proceedings of the ninth annual international ACM conference on International computing education research*.
25. A. Wallace, "Social learning platforms and the flipped classroom," 2013 Second International Conference on E-Learning and E-Technologies in Education (ICEEE), 2013, pp. 198-200, doi: 10.1109/ICeLeTE.2013.6644373.
26. Jasmine paul,"A Comparative Analysis of Student Performance in an Online vs. Face-to-Face Environmental Science Course From 2009 to 2016",Frontiers in Computer Science,Vol 1,2019,DOI=10.3389/fcomp.2019.00007 https://www.acm.org/binaries/content/assets/education/ce2016-final-report.pdf
28. Anderson, Lorin W., and David R. Krathwohl, eds. 2001. Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives.New York: Addison Wesley Longman, Inc. https://www.gnomio.com/