On the Use of MT2 for Computer Networking Courses During the Pandemic and Beyond

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Abstract

The paper studies the method for online teaching using Multi-Track Modular Teaching (MT2). MT2 is an advanced teaching-learning method for better training of students with deep skills. Covid19 pandemic and the associated lockdown periods, coupled with the requirements of social distancing, have played a major disruption in the academic processes across all the world's universities. Due to the inability to conduct physical classes and lectures, most universities have opted for online classes using video conference tools. One way to make the computer networking classes, during lock-down periods, more effective is to use the Multi-Track Modular Teaching (MT2) technique which organizes a course into multiple tracks and modules. This paper presents the mod?ifications carried out to MT2-based computer networking course and experiences from teaching it online during the lock-down period. While the online classes offered an alter?native to the completely disrupted teaching and learning process, observations on their effectiveness reveal certain important considerations in order to make them more useful. Results from a feedback survey of the students who under?took the course is also provided in this paper, giving insights to certain difficulties and issues in the conduct of online classes in developing countries.

On the Use of MT2 for Computer Networking Courses During the Pandemic and Beyond

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ABSTRACT

Covid19 pandemic and the associated lock-down periods coupled with the requirements of social distancing have played a major disruption in the academic processes across all the world's universities. Due to the inability to conduct physical classes and lectures, most universities have opted for online classes using video conference tools. One way to make the computer networking classes, during lock-down periods, more effective is to use the Multi-Track Modular Teaching (MT2) technique which organizes a course into multiple tracks and modules. This paper presents the modifications carried out to MT2-based computer networking course and experiences from teaching it online during the lock-down period. While the online classes offered an alternative to the completely disrupted teaching and learning process, observations on their effectiveness reveal certain important considerations in order to make them more useful. Results from a feedback survey of the students who undertook the course is also provided in this paper, giving insights to certain difficulties and issues in the conduct of online classes in developing countries.

1 INTRODUCTION

Covid19 pandemic has disrupted the teaching and learning process followed by the universities across the world. Given the current long-drawn fight against Covid19, new methods and best practices are essential to manage the academic activities through online methods. Most universities have managed the classes through online means utilizing the video conference platforms. Many other universities used a combination of methods including, but not limited to, the following: (i) online classes, (ii) presentation slides with instructor's voice embedded, and (iii) providing links for courses and materials from Massive Online Open Course-ware (MOOC) platforms such as [1] [2][3]. Thus, Covid19 pandemic taught many new lessons on how to manage academic activities during lock-down periods where social distancing is critical.

Multi-Track Modular Teaching (MT2) is a teaching-learning method that defines multiple tracks within an academic course with each track consists of a certain set of modules for effective and all-round learning. MT2 provides a better organization to handle courses where research-oriented teaching is essential. Computer networking course was taught in our university using the MT2 method during January-June 2020 semester. Due to the Covid19 pandemic, the course was disrupted due to the announcement of national lock-down in the middle of the semester.

Continuation of the semester's classes during the lock-down period was carried out through online method using a combination of video conference platforms such as Zoom [4], GoToMeeting [5], Google Meet [6] and Skype [7] for various courses. The MT2-based computer networking course was carried over using Zoom online classes making suiable adaptation to the track's contents.

This paper briefly discusses the MT2 method and further presents the modifications that were made to the modules of an MT2-based course in order to better handle and organize the academic course during the Covid19 pandemic. Further, how the MT2 approach can be utilized for handling the online courses during future pandemics, focusing on future computer networking education, is also discussed. Real-world experiences on conducting online classes from the current pandemic period from both the instructor's and students' perspectives are also presented.

The organization of the rest of the paper is as follows: Section 2 briefs the MT2 method and Section 3 discusses the modifications that were carried out for MT2-based course modules in order to suit the classes during Covid19 pandemic period. Section 4 presents the perspectives and experiences of the instructor as well as the students when using online courses during Covid19 pandemic where the lock-down overlapped about 60% of the semester-long course. Section 5 briefly presents discussions on certain issues pertaining to online classes and Section 6 concludes the paper.

2 MULTI-TRACK MODULAR TEACHING

MT2 is a class organization method [13] that helps an instructor to plan a course in multiple tracks. Each of the tracks can be utilized for a specific set of activities within a course as per the needs of the instructor. For example, the sequence of lectures delivered by an instructor can be defined as the main Lecture track as shown in Table 1. In addition to the

main Lecture track, the instructor can also define various supporting tracks, consisting of various complementary activities, to supplement and enhance the learning obtained in the lecture track.

Track-1: Lecture track	Track-2: Activity-1 Track	Track-3: Activity-2 Track	Track-4: Activity-3 Track
Lecture module 1	Activity-1 module 1	Activity-2 module 1	Activity-3 module 1
Lecture module 2	Activity-1 module 2	Activity-2 module 2	Activity-3 module 2
⋮	⋮	⋮	⋮
Lecture module N	Activity-1 module M	Activity-2 module K	Activity-3 module Q

Table 1: MT2 defines parallel tracks and each track contains various modules. The main track is usually a lecture track and the rest of the tracks support and complement the main track to enrich the course. The number of modules in each track can be different as represented by the letters N, M, K, and Q.

Track-1: Lecture track	Track-2: Writing track	Track-3: Networking Experiments track
Introduction and Theoretical analysis	Writeup-1 [9]	Experiment 1: Network traffic capture and analysis.
Application layer	Writeup-2 [10]	Experiment 2: HTTP Traffic Analysis Experiment
Transport layer	Writeup-3 [11]	Experiment 3: Zoom Video Conference Traffic Capture and Analysis
Network layer		
Datalink layer		Experiment 4: Sliding Window Protocol Implementation

Table 2: MT2 tracks defined for the online Computer Networks course during the Covid19 pandemic lockdown.

Each track, in an MT2-based course, is defined for a specific activity that enhances the lessons learned from the lecture track. The tracks are concurrently conducted considering any dependencies between the modules of the tracks. The key benefits of MT2 are the following: (i) formalized structure for multi-modal teaching, (ii) enhanced quality of teaching, (iii) enhanced students' engagement, (iv) deeper and better understanding of the subject, (v) enhanced students' confidence, (vi) removal of students' fear factor, (vii) improved employability of students, and (viii) focused skill training for students to carry out special education such as research. More details on MT2, including design of tracks and modules, can be found in [13]. MT2 can be customized to deal with situations such as Covid19 pandemic where the contents of the track can be suitably altered as discussed in the following section.

3 MT2 FOR COMPUTER NETWORKS COURSE DURING COVID19

Government of India declared national lock-down starting from March 23, 2020 with a very strict set of guidelines. While the lock-down was relaxed a few times, the increasing number of Covid19 infections resulted in only continuing the restrictions. The January-June 2020 semester at our university, the Indian Institute of Space science and Technology (IIST) [8], had completed only about a third of the semester when the lock-down was declared.

During the January-June 2020 semester, the AV 321 Computer Networks course, was already in progress when Covid19 related lock-down was announced in India. For this Computer Networks course for the Undergraduate students, MT2-based approach was employed during the semester with three tracks. Table 2 depicts the three tracks used for the course. The three tracks were: (i) Lecture track, (ii) Writing track, and (iii) Network Experiments track. First track consisted of a Lecture track covering all the course lectures, second track provided technical writing improvements to students, and the third track defined a set of network experiments which could give the students exposure to real world network observations. The Track-1 followed a standard UG textbook on computer networks [12] and tracks 2 and 3 followed instructor-defined activity modules.

Due to the declaration of the lock-down, the main mode of interaction between the instructor and the students in Track-1 was modified to online lectures using a licensed video conferencing tool. The Track-2 required no modification because the track consisted of write-up preparation on a set of carefully chosen path breaking papers in computer networking. Track-3 was the most affected due to the

physical-to-online transition. Experiments defined in Track-3 were modified suitably to be carried out at students' homes using their computers. That is, Experiment 3, in Track-3, was redesigned to study the traffic captured from the students' computer during the online classes based on Zoom video conference platform for 30 minutes, analyze the traffic, and prepare a document for submission. Students collected the network traffic during the online lecture and conducted detailed traffic analysis of Zoom video lecture sessions. Many students made useful insights using the experiment. Experiment 4 was defined to build a Go-Back-N sliding window protocol based sender and receiver over UDP transport layer. The Go-Back-N protocol was required to ensure reliable delivery of data over UDP. To test the protocol's functionality, the receiver should drop every k^{th} packet where k is obtained as $MAX(3, p)$ where p is the the last digit of the student's roll number. Suitable modification was made on this experiment as well, in order to carry this experiment out in a single system owned by the students. We found that online classes limit the possibility for experiments due to the limited computing and networking resources available to students.

While the lecture track was completely moved over to online video conference, thereby continuing the academic activity, the online experience of the students were not as impressive as the equivalent physical in-class room lectures as can be observed from the survey results reported later in this paper. The observations of instructors about the main reasons behind the dissatisfaction of the online lectures are the following: (i) many students could not get access to the Internet through broadband connectivity, (ii) students with low Internet bandwidth could not get consistent bandwidth resulting in discontinuity in audio and video content delivery, (iv) student-to-instructor interaction was minimal and insufficient, (v) online lecture delivery speed was observed to be faster than the physical class-room lectures, and above all the (iii) instructor could not obtain the much needed feedback in-terms of facial expressions and body language from students.

4 PERSPECTIVES OF ONLINE CLASSES DURING COVID19 PANDEMIC

The MT2-based design of computer networks course provided both theoretical knowledge, writing skills as well as experimental exposure to computer networks students. In order to understand the impact and perception of the online classes during the Covid19 pandemic, we conducted a survey among the students who undertook the computer networks course discussed in this paper. About 53% of the students who took the course participated in the survey. In

this section, we discuss some of the statistics, resources availability, issues faced during the online classes, and above all the observations and opinions made by the students.

4.1 Internet connectivity statistics during the Covid19 lock-down enforced online classes

As part of the survey of types of Internet connections used by the students who undertook the computer networks course, we obtained very surprising results as shown in Figure 1. More than half the respondents (57.1%) used 4G mobile broadband connections with about 10.7% of students having only 3G/2G mobile Internet. 14.3% of the students only used cable-based wired Internet connections. Optical fiber-based broadband internet was available only to 7.1% students. Overall, only 32.2% of students had used wired Internet whereas a much larger fraction of about 67.8% students used wireless Internet during the online classes of computer networks course.

4.2 Students' observations on the Internet connection stability during the online classes

One of the questions of survey was about the Internet connection disruptions faced during the classes. Figure 2 shows the results of the survey. Only 32.1% of the students reported stable interruption free Internet access during the classes. A large fraction of students (42.9%) reported interruptions during at-least half the classes. Many factors contributed to the instability of Internet during the online classes with the main reason attributed to the low and fluctuating bandwidth of mobile broadband networks.

4.3 Downlink and uplink bandwidth of Internet connections

Bandwidth availability in countries such as India still comes at a premium as evident from the downlink and uplink data rates of connections used by the students for attending the online classes. Figure 3 shows downlink Internet bandwidth of the connections where only 32.1% students reported a moderate amount of bandwidth in the range of 1-5Mbps. About one third of the students in the class depended on low data rate links of less than 1Mbps. About 7% students reported 5-10Mbps and 10.7% reported having greater than 10Mbps bandwidth.

Similar to the downlink bandwidth, the uplink bandwidth also has been reported as shown in Figure 4 where about 40.7% of students reported less than 1Mbps uplink speed. Zoom video conference tool works well only with 1-5Mbps bandwidth which only 18.5% students reported to have. While
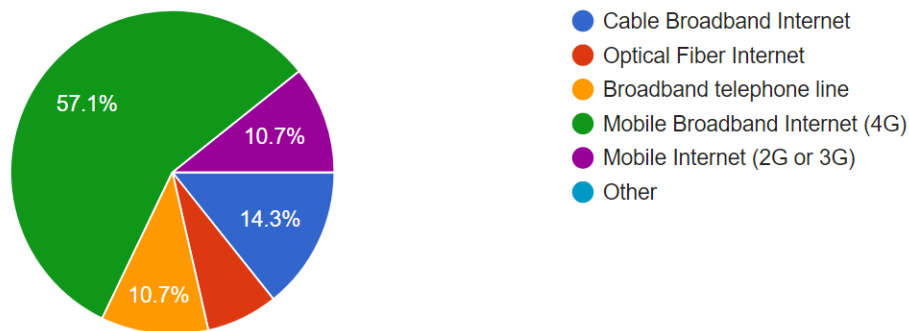
Figure 1: Types of Internet Connections Used by the Students to Attended Online Computer Networking Classes.
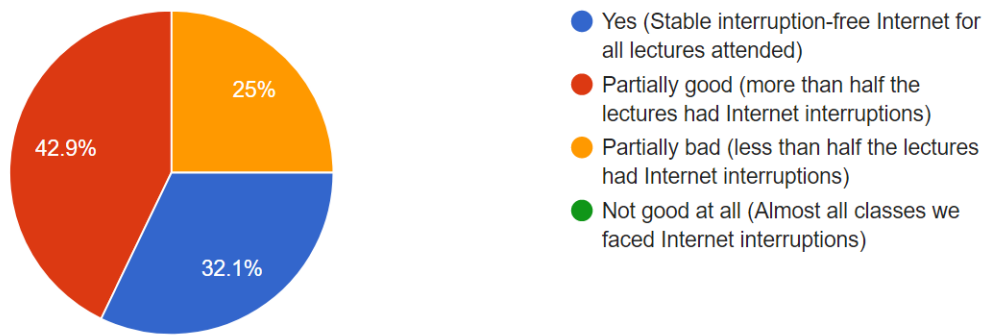

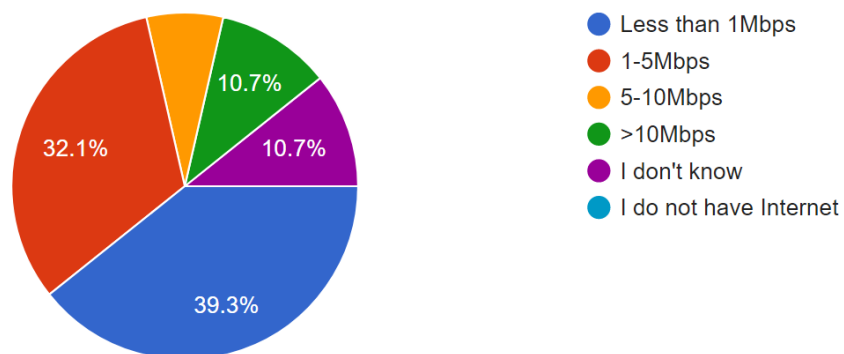**Figure 2: Internet Connection Stability During Online Classes.**

Figure 3: Downlink Internet Bandwidth of Internet Connections Used by the Students.

only 7% students have bandwidth of 5-10Mbps for uplink, about 11.1% students reported having more than 10Mbps.

In some of the cases where students informally mentioned that their allowed volume of data exceeded during the online classes. In order to estimate the percentage of students with limited volume based service level agreement with the Internet providers, we had included a question to that effect. The results related to this question is shown in Figure 5 where 75% students reported volume-limited Internet connections.
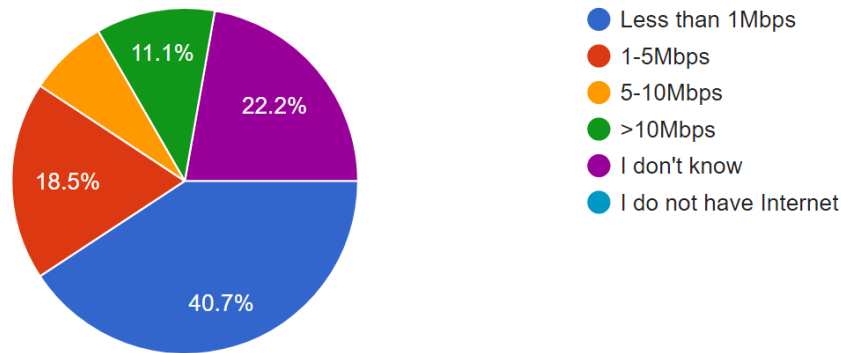
Figure 4: Uplink Internet Bandwidth of Internet Connections Used by the Students.
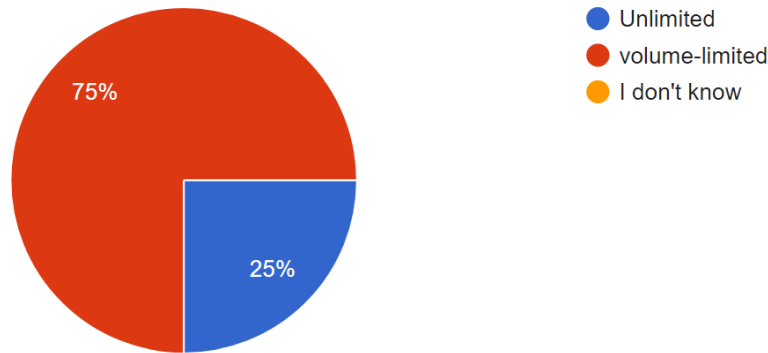

Figure 5: Statistics of Unlimited/Limited Volume-based Internet Connections Used by the Students.

4.4 Students' observations on the effectiveness of the online classes

Figure 6 shows the effectiveness of online classes as perceived by the students who undertook the computer networks course discussed in this paper. About 39.3% of students reported that their perceived benefit for online classes is only half as the physical class room lectures. 21.4% of students estimated the online classes provided them about 75% or equivalent learning as a physical class room session. A quarter fraction of the students (25%) estimated that online classes only about 25% beneficial compared to physical class room sessions. About 7.1% students reported to benefit 90% of the physical class room experience from online classes. Further, a very small percentage of students (3.6%) reported to have benefited only 10% or less of the physical class room experience. These results indicate that the Internet connectivity improvements can be very useful for enhancing the effectiveness of online classes in the event that universities are continuing to pursue the online mode of teaching and learning.

We compared the perceived effectiveness of online classes of the computer networks course compared to the rest of the courses. The observations of students' perception from 247 students belonging to undergraduate, post graduate, and PhD programs is provided in Figure 7. It can be found that 38.5% of students perceived the online classes as only 50% effective compared to the physical class room lectures. Further about 19.8% of students estimated the online class as equivalent to only 75% of the physical classroom sessions and 18.6% found the online classes worth only a quarter of their physical equivalent. Surprising element is the matter of 11.3% students finding the classes equivalent only to less than 10% of the physical class room lectures.

In comparison to the average perception across several courses, the computer networks course where MT2 was employed appeared to be at certain advantages even though full-fledged use of MT2 could not be carried out due to the Covid19 pandemic and related lock-down measures. Table 3 compares the estimates made for all other courses in comparison to the MT2-based computer networks course.

- ● I get only 10% of the physical classroom lecture from an online class.
- ● I get only 25% of the physical classroom lecture from an online class.
- ● I get only 50% of the physical classroom lecture from an online class.
- ● I get about 75% of the physical classroom lecture from an online class.
- ● I get 90% or more of the physical clas…
- ● I don't know

Figure 6: Perceived Effectiveness of Online Classes Compared to Physical Classroom Sessions for the Computer Networks Course.

Question	Percentage of students responded across all courses excluding computer networks course	Percentage of students responded in MT2-based computer networks course
I get 90% or more of the physical class room lecture from an online class	8.1%	7.1%
I get 75% of the physical class room lecture from an online class	19.8%	21.4%
I get only 50% of the physical class room lecture from an online class	38.5%	39.3%
I get only 25% of the physical class room lecture from an online class	18.6%	25%
I get only 10% of the physical class room lecture from an online class	11.3%	3.6%
I don't know	3.6%	3.6%

Table 3: Comparison of perception of effectiveness of online classes with MT2-based computer networking course during the Covid19 lock-down.

Table 4 shows the cumulative results of perception of students gathered from online classes in comparison to physical class room lectures. In order to avoid the element of instructor's teaching abilities, the questionnaire was created to compare the physical class room lectures with its class room equivalent. Note that the students had attended about 30% of the semester's classes in physical class room mode of lecturing before the start of the online lecture mode enforced by the Covid19 lock-down guidelines. Two observations can be made from the results in Table 3: (i) online classes are only partially effective compared to the physical classroom lectures and (ii) MT2-based online lectures have slight advantage compared to non-MT2 based courses. Based on the observations from Table 4, 92% of students gained at least a quarter of the equivalent class room lectures compared to 85% across all the rest of the courses.

4.5 Preferred duration of online classes

We further conducted an institute-wide survey across several classes in order to obtain perceptions of the students community. The statistics presented here consists of 246 responses from various classes spanning undergraduate, post-graduate, and PhD students. For the question on the appropriate duration of online classes, the results are presented in Figure 8. The largest fraction of about 28.9% students favored 50 minutes online classes whereas the second largest fraction of 24% students favored only 40 minutes-long online lectures. About 19.5% students favored 60 minutes long online classes at the same time, only a very small percentage of students (2.8%) favored long duration of more than 2 hours. 14.6% students favored 60-120 minutes long lectures whereas only 8.1% favored 30 minutes long lectures. In summary, majority students preferred less than an hour-long online lectures.

Figure 7: Perceived Effectiveness of Online Classes Compared to Physical Classroom Sessions for Courses Other than Computer Networks.
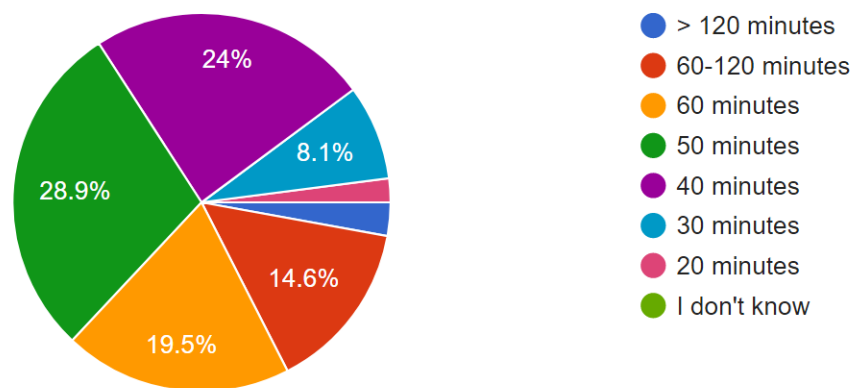

Figure 8: Preferred Duration for Online Classes.

4.6 Preferred mode of lecture delivery

We present in Figure 9, the opinion collected from 246 students from various academic programs during the Covid19 pandemic on what their preferred mode of lecture delivery is. More than half the students preferred live online classes (51.2%) out of which 46.7% preferred live online lectures to be supplemented with recorded videos. 25.2% of students preferred recorded videos with discussion sessions for clearing doubts. 7.3% preferred only recorded videos with no live interactions with the instructors. Small percentages of students preferred slides with audio lectures and slides with lecture notes, respectively, at 5.7% and 6.9%.

5 DISCUSSIONS

MT2 provides a method to organize the interaction between the instructor and the students particularly for online classes. Modules within the tracks of MT2-based course can be adapted

to handle the restrictions of the situations such as those during Covid19 pandemic lock-down.

Interruptions due to the Internet connectivity remained as a notable issue against the effective conduct of online courses. Covid19 pandemic underlines the need to immediately address the issue of digital divide.

In addition to the Internet related disruptions, students faced many other disturbances during the online classes. Principal among them is the disturbances or background noise of their home environments. A conducive environment for attending online classes is very much needed for effective online classes.

6 CONCLUSIONS

Covid19 has affected teaching and learning processes all around the world. Most universities have chosen to use online class rooms over video conference software to conduct the classes. This paper described the way how Multi-Track
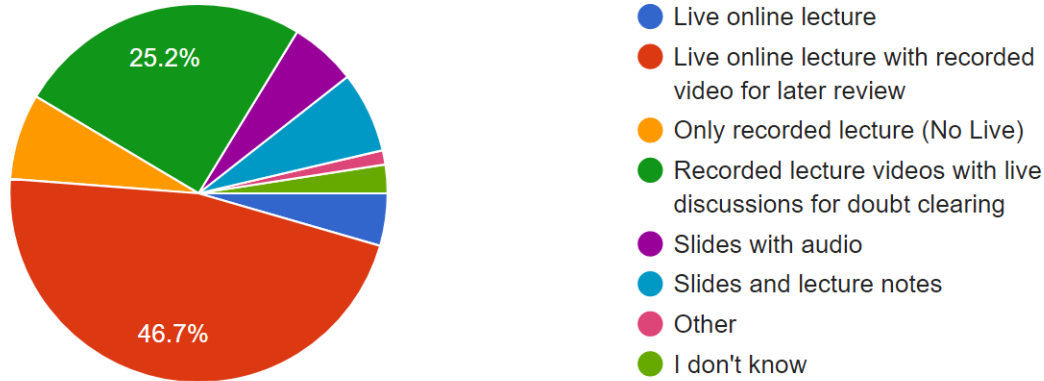
Figure 9: Preferred Mode of Lecture Delivery.

Cumulative of questions	Percentage of students responded across all courses excluding computer networks course	Percentage of students responded in MT2-based computer networks course
I get 75% or more of the physical class room lecture from an online class	27.9%	28.5%
I get 50% or more of the physical class room lecture from an online class	66.4%	67.8%
I get 25% or more of the physical class room lecture from an online class	85%	92%

Table 4: Comparison of cumulative perception of effectiveness of online classes without and with MT2.

Modular Teaching (MT2) has been used for teaching Computer Networks course during the Covid19 lock-down period. MT2 is a teaching method that divides the course into several parallel and complementary tracks and each track containing activity modules. During the Covid19 lock-down period,

suitable modifications were carried out for the modules of the tracks of the MT2-based course to better suit the needs of the students who attended online classes from a variety of locations using a diverse set of Internet access methods. Statistics about the access types, disruptions, and perceptive effectiveness of online classes by the course students were also presented in this paper.

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