E-LEARNING AMID COVID-19 PANDEMIC SITUATION: A CASE STUDY

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ABSTRACT
Online teaching platforms have gained popularity as a mode of education, complementary to traditional teaching learning process based on classroom interaction. The teaching-learning process has been categorized into three classes: Classroom teaching, Direct online teaching and Indirect online teaching. All three types of classes have different benefits and limitations. Amid the COVID-19 pandemic, the lockdown and social distancing norms have suddenly forced the educators to consider the online platforms as only teaching option. This work aims at an analytical assessment of the entire teaching learning process via online mode, based on the survey of a group of college students of Undergraduate course. Several important conclusions have been drawn about the potential of online teaching to become the alternative of traditional classroom-based teaching in India.

1. INTRODUCTION

The education system, since ancient time, has always been based on vis-a-vis meeting between teachers and students, inside a classroom, equipped with tools of teaching- first it was the books, and then with the advancement of technology it was the blackboard or whiteboard, the ICT (Information and Communication Technology) enabled smart devices like projectors etc. However, a paradigm shift started to take place in the education sector ever since the digital revolution took place across the globe and host of e-learning platforms were launched and became popular over time. Right now, E-learning is a rapidly growing industry. It offers the ability to share material in all kinds of formats such as videos, slideshows, word documents, and PDFs. Conducting webinars (live online classes) and communicating with professors via chat and message forums allow learners to keep in touch and discuss course-related matters, whilst providing for a sense of community. Apart from the growth and spread of Internet facility, the technological advancement in hardware and software industry has been very crucial in the education sector. Ansari, M. & Tripathi, A. (2017) and Camilleri, A.C. & Camilleri, M.A. (2019) have shown how development of multifunctional mobile phones and well-designed mobile apps are contributing heavily towards efficient learning. There are countless online courses offered by reputed institutions like MIT and Stanford University and online learning apps like ByJu, Khan Academy and Udemy, making the most of the internet and bringing education to people, who wouldn't previously have been able to attend a college due to geographical or time constraints. Appana, S. (2008) has mentioned in her work that:
"At the same time, economic pressures make it difficult for individuals to take several years off from work to attend a university on a full time basis. Online graduate degrees from a wide range of universities and institutes, for example, ITT Technical Institute and the University of Phoenix offer the opportunity for students to continue their education while at the same time continue working in their field of business."

These two modes of teaching, namely the offline teaching requiring a classroom and the online teaching requiring e-learning platforms, have been complementing each other in a nice way until a global pandemic made a blow to our regular lifestyle in the beginning months of 2020. The novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has spread across the world like wildfire according to Worldometer Coronavirus Live. According to a study by Verity, R. (2020), it is quite difficult to prevent the spread because it is not only contagious but also invisible: an infected person may not show any symptoms at all (asymptomatic).

In order to control the rapid spread of corona virus through human contact, the concept of "social distancing" (maintain a gap of 6 feet between any two individuals) was introduced and it is reported in The Business Insider on 13th April, 2020, that a third of the global population went on corona virus lockdown for different periods of time. All educational institutions were shut down. In West Bengal for example, they are closed since 15th March, 2020. In this scenario, online classes became the only alternative for the continuation of academic activity.

The Internet penetration rate or the internet accessibility of the Indian population, however, is very despairing. According to Worldometer Indian Population Live,

- Indian population in 2019: **1.366 billion**
- Rural population in 2019: **895 million**

- Urban population in 2019: **471 million**

Now, according to a report prepared by Internet and Mobile Association of India (IMAI) and Nielsen on "Digital in India" published on 7th May, 2020, as of November, 2019:

- Number of Active Internet users in India: **503 million** (37% of total population)
- Number of Active Internet users in rural India: **227 million**
- Number of Active Internet users in urban India: **205 million**
- Number of children between 5-11 years old using internet of family member: **71 million**
- 99% of all users access Internet through mobile
- 88% are connected to 4G network

Again, "Key Indicators of Household Social Consumption on Education in India" NSS 75th Round (July 2017 - June 2018) states that, only 14.9% of rural and 42% of urban households in India have Internet facility. All these are the issues regarding having internet access or not. Now having internet access is not sufficient for an online class. One needs to have a good quality internet connection for accessing e-resources. Sharma, P.K. and Pandey, V., (2015) clearly states that,

"The main constraints in ubiquity are, limited availability of spectrum, higher tariff of Internet usages, non-availability of last mile broadband connectivity, non-availability of electricity, non-availability of mobile networks, less awareness about e-Services and quality of services rendered. As on 30th April,2015, the wired broadband density was only 1.24% and wireless internet users are only 20 Crore."

Also, in their work they represent a comparative data, drawing parallels between the internet speed of different countries. There they have shown that internet speed in India is only 2.3 Mbps, while that of South Korea and US is 23.6 Mbps and 11.9 Mbps respectively. The situation has not changed much with time, since on April 2020, the Speed test Global Index ranks India 132nd worldwide for mobile broadband performance. The average download speed is 9.81 Mbps and upload speed is 3.98 Mbps. The real data speed available to a large section of digital population of India is however far smaller than this, as reported by Moneylife, 24th January, 2020.

Integrating all these issues into one equation, it is evident that online teaching has attracted a lot of attention of both the intelligentsia as well as the general public. On one hand, there has been a growing demand for the online teaching from those who can access the internet facilities properly, because the psychological effect of lockdown and the panic created by the pandemic has been worse for the students and they are looking for an escape route. On the other hand, there are numerous students as well as teachers who do not have access to online facilities and lack proper training for the same due to various reasons.

In an attempt to assess the overall situation of this transition from the classroom-based to Internet-based teaching-learning process, we have carried out a qualitative as well as quantitative study of the various e-learning platforms which became popular among the educators during the lockdown and the response of the students towards it.

2. LITERATURE REVIEW

The constant innovation and upgradation of the digital devices as well as technology (Veeramanickam, M.R.M. & Mohanapriya, M. (2016)) has led to the obvious upsurge of a spectrum online learning platforms. Oye, N.D., Salleh, M. & Iahad, N. A. (2012) has discussed at length about different tools and methods employed in e-learning. Even, researchers have gone on to predict that, online education is going to become mainstream by 2025 (Palvia, S. (2018)). Mobile learning, among other modes, have already gained momentum among the students' community (Ansari, M. & Tripathi, A. (2017) and Camilleri, A.C. & Camilleri, M.A. (2019)).

However, online classes have several demerits as well. A quick literature survey suggests that, technological inefficiency and insufficient data speed is a huge drawback for the students attending online class (Appana, S. (2008)). This creates the infamous "Digital Divide": the group of "Have-s" and "Have-not-s", thereby denying the right to education of a student. In some online courses, depending on its design, there may be lack of academic and social interaction between teacher and the students as well as between different students. Lack of active campus life and community feelings may have adverse effects on persistent learning and group discussions (Rovai et al (2005), Donlevy (2003)). Students who are not disciplined or self-motivated do not benefit much from online learning (Saveney (2005)). Online education from the educators' perspective have been studied in the work by Sofat, R. & Sharma, R. (2020). Gilbert, B. (2015) summarizes the benefits and challenges of online education in a compact manner.

The availability of both the platforms is one thing. But the pandemic situation has tipped the balance totally in favour of online learning. Goplani, M. and Gupta, A. (2020) has discussed at length the effect of COVID crisis on the educational institutions in India. 2020, in a sense, has presented a unique situation before us. On one hand, we are facing a serious handicap in the traditional teaching learning mechanism. On the other hand, there has been digital revolution in recent times, especially during lockdown, which can ease the situation and might usher in a new era in online teaching learning mechanism. Dhawan, S, (2020) has carried out a detailed SWOC analysis of online education in her work. A proper assessment of the complex scenario is impossible without analysing the realistic situation from the students' and teachers' perspective. An interesting case study on college students has been done in the work by Patricia Aguilera-Hermida, A. (2020). In another work, we can see how an educational institution in India is dealing with the new situation and continuing its academic activity in digital mode (Mishra, L., Gupta, T. and Shree, A. (2020)). Many innovations are coming our way to cope with the situation and utilize the situation to improve the future of our students, one such work being the one by Martinez, J. (2020). In short, online education is no more a matter of choice but a compulsion (Lederman, D. (2020)). Hence the motivation for this case study: How good an alternative online learning is?

3. MATERIALS AND METHODS

In West Bengal, all educational institutions have been closed since 15th March, 2020 and will remain so until 30th June, 2020. During such a long period of lockdown, a large number of students started to feel confused and uncertain about what fruitful and positive things can be done in the confinement days and who will give them proper guidance regarding this. In this bleak scenario, many teachers took to online teaching in order to engage the students into academic activities, taking help of the following online tools:

1. **Board work options:** Board work is essential for effective teaching, especially for disciplines where calculations, diagrams or other visual cues are inevitable. Some teachers also use normal blackboard or whiteboard and record the video of the class, which requires proper video recording tools as well. In such mode, file size usually becomes a big issue. If original blackboard or whiteboard is not available, devices like pen tab is essential for any proper board work. The movement of the pen on a tablet is recorded automatically in some digital board like 'Openboard' software and also the whiteboard tool provided in some video calling apps like Zoom or Cyberlink U messenger by the interfacing software. However, in that case the educator is unable to see the students as the laptop or mobile screen is occupied by this digital board. In our case none of the above-mentioned gadgets was available to the educator because the educator is a professional classroom-based teacher and lockdown made it impossible to avail of the above-mentioned devices. This grave inconvenience has been faced by many educators who shifted to online teaching because of lockdown. For these course instructors, the only options are digital boards, on which one can manage to write with fingertip (in case of a smartphone) or mouse (in case of laptop).

2. **Zoom cloud meeting app**: Zoom is a cloud-based video conferencing platform that can be used for face-to-face video conferencing, audio conferencing, webinars, meeting recordings, and live chat. The free version allows a maximum of 40 minutes session with maximum 100 number of participants. We have found that it consumes little amount of data. Also, there is the option of screen sharing, whiteboard sharing and recording the whole meeting, maintaining thereby a cloud back up. However, after gaining a roaring popularity in the academia as well as corporate sector, suddenly this app ran into controversy for not providing end-to-end encryption and alleged sale of customer data to Dark Web.

3. **Facebook and Youtube live sessions**: These options are very popular because here although video conferencing is not allowed, the lecture sessions are live and students can post questions during lecture via live chat option. Most importantly, the entire lecture remains there for the students to check out at any time if they miss the live class. One problem ofcourse is the lack of boardwork facility, which is available with Zoom app as there one can share the screen or whiteboard. This problem can be overcome by using third-party software like Open Broadcaster Software. These types of software can record the screen visuals and audio input and stream the recording live via Youtube. By using Openboard software, boardwork can be done on the screen and the same can be streamed live via Youtube.

4. **Uploading video content in Youtube**: In this method there is practically no live interaction: neither video conferencing nor live chat. But the advantage point is that, there is absolutely no compulsion on the part of the students to appear online at a particular time to attend the lecture. The lecture alongwith boardwork (if necessary) can be recorded by any screen recording software or app and posted to the youtube channel of the educator. The time constraint is completely lifted here. This factor has become very crucial especially during lockdown because millions of people are accessing internet while sitting at home, resulting in poor data connectivity in many regions

during peak working hours. So far as interaction is concerned, the students later can come back with questions to the teacher over telephone or any suitable media.

5. **Uploading audio content in Whatsapp group**: In case available internet bandwidth is not sufficient for any video conferencing or Youtube streaming, Whatsapp group can be created with the students. There, audio clip discussing any text can be shared with the students easily.

6. **Sharing assignments and study materials via Google Classroom app, email and in Whatsapp group**: Google Classroom is a free collaboration tool for teachers and students. Teachers can create an online classroom, invite students to the class then create and distribute study materials, URL of any relevant webpage, any relevant Youtube video and also, they can post assignments. Within the Google Classroom students and teachers can have conversations about the assignments and teachers can track the student's progress. All the updates are grouped into a separate inbox in Gmail and the entire collection of materials as well as updates is stored in a separate folder in the drive. Thus, all the materials shared via Google Classroom is easily accessible from any device: any smartphone or computer.

7. **Class test carried out by Google form, Google Classroom and Camscanner app**: Google Forms is a tool that allows collecting information from users via a personalized survey or quiz. Google Forms includes 9 question types (Short Answer, Paragraph, Multiple Choice, Checkboxes, Dropdown, Linear Scale, Multiple Choice Grid, Date and Time). But quizzes only work with multiple choice, checkbox, and drop-down questions. The information is collected and automatically connected to a spreadsheet. The spreadsheet is populated with the survey and quiz responses. Google Classroom app is also very useful where class test questions can be created, points can be allotted and a particular date and time can be set for the students as a deadline of submission of the answer. If a student submits answer past the deadline, they are marked separately. The question types are however limited to two: short answer type and multiple-choice type. Also, no summary of the student responses is prepared by the app. The individual answers can be evaluated and the teacher can send back the evaluated answers along with grade points to the students.

The Cam Scanner app has emerged as an excellent support system where books or hand-written study material can be scanned and exported easily in two formats: image and pdf. The scan quality is very good and scanned files can be shared directly via email, WhatsApp or Google Classroom. Exams can be conducted by sharing question paper over WhatsApp and students can send back answer scripts via same platform.

7. **Other video conferencing tools**: Cyberlink U messenger, Google Meet, Teamlink, Skype etc. Cyberlink U messenger allows maximum 25 participants and 30 min time span for any meeting. Google meet allows 150 participants, so its more suitable for a large class. However, it does not include whiteboard tools. Compared to the above merits and demerits, Skype has the facility of 24 hours time limit for meeting and allows 50 people in a meeting. Also screen sharing feature is included in Skype.
A comparative chart of various video conferencing techniques is given below in Table 1:

TABLE 1: Comparison between different video conference tools

Product	**Maximum Participants**	**Time Limit**	**Whiteboard**	**Cost**
Google Meet	150	None	No	Free till September
Zoom	100	40 min	Yes	Free
Skype	50	24 hrs	No	Free
Cyberlink U	25	30 min	Yes	Free
Teamlink	300	None	Yes	Free
Facebook Messenger	50	None	No	Free

The case study has been carried out on college undergraduate students who study laboratory-based subject. The following parameters have been taken as the Students' Performance Indicator (SPI) which describe the overall participation and understanding of an individual student:
i) Percentage of attendance
ii) Percentage of students submitting assignments in time
iii) Percentage of students obtaining grade "A" in Class Test
iv) Percentage of students turning up with class queries

The above aspects have been studied and compared in three modes of teaching:

1. **Classroom teaching (Space and time restricted for face-to-face Live interaction)**: students need to travel to the college on time in order to learn and participate in vis-a-vis live interaction.

2. **Online teaching via direct contact (Space unrestricted but Time restricted for face-to-face Lecture Delivery)**: students do not need to travel but be online (in Zoom, Skype etc.) on time in order to learn and participate in vis-a-vis live interaction. Such type of teaching requires high speed data connectivity.

3. **Online teaching via indirect contact (Space and Time both unrestricted and no face-to-face Lecture Delivery)**: students neither need to travel nor need to maintain any particular time to be able to attend the class as there is no vis-a-vis delivery of lecture. The study material is made available in pdf or word format via Google Classroom and the material is explained by video and audio recordings, shared through Youtube channel, Whatsapp etc. The students can access these at their convenient time. They can interact with the teachers via suitable methods afterwards. Data requirement for such type of class is moderate and manageable.

The contraints of different teaching mode is represented in Figure 1, showing that the indirect online teaching has least number of constraints. The collected data have been analysed and graphically compared to draw several important conclusions.

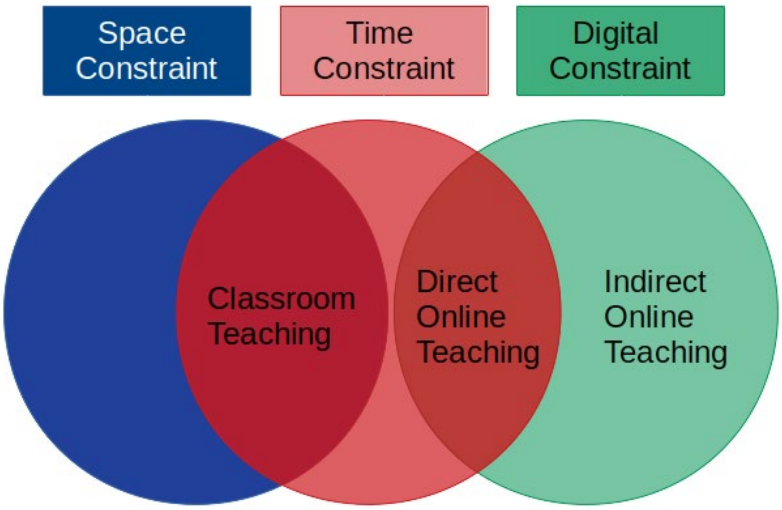

Figure 1: Different constraints for different teaching modes.

4. RESULT AND DISCUSSION

4.1 Result

The results have been summarized in Table 2 and the same has been graphically represented in Figure 2 and 3.

This survey has been conducted from 20.03.2020 to 20.05.2020. We have divided the students under survey into three groups according to their access to online facility:

1. "Zero access group" refers to those having no smartphone or laptop.
2.

2. "Difficult access group" refers to those having poor data connectivity and/or no personal smartphone or laptop and borrow from others.

3. "Easy access group" refers to those students who have personal smartphone or laptop and a stable data connectivity, allowing smooth streaming of online resources.

The size of these three groups are given in Table 3 and Figure 4.

TABLE 2: Students' Performance Indicator (SPI) for three different modes of teaching

SPI (Students' Performance Indicator)	**Classroom Teaching (% of total students)**	**Online Teaching via direct contact**		**Online Teaching via indirect contact**		
		% of total students	**% increase (over classroom teaching)**	**% of total students**	**% increase (over classroom teaching)**	**% increase (over online teaching by direct contact)**
% of Students' attendance	67.9	65.4	-3.6	82.7	21.8	26.4
% of students submitting assignment on time	46.9	61.7	31.6	67.9	44.7	10
% of Students with grade "A" in Class test	43.2	53.1	22.9	55.6	28.6	4.7
% of Students coming back with queries	23.5	38.3	63.2	46.9	100	22.6

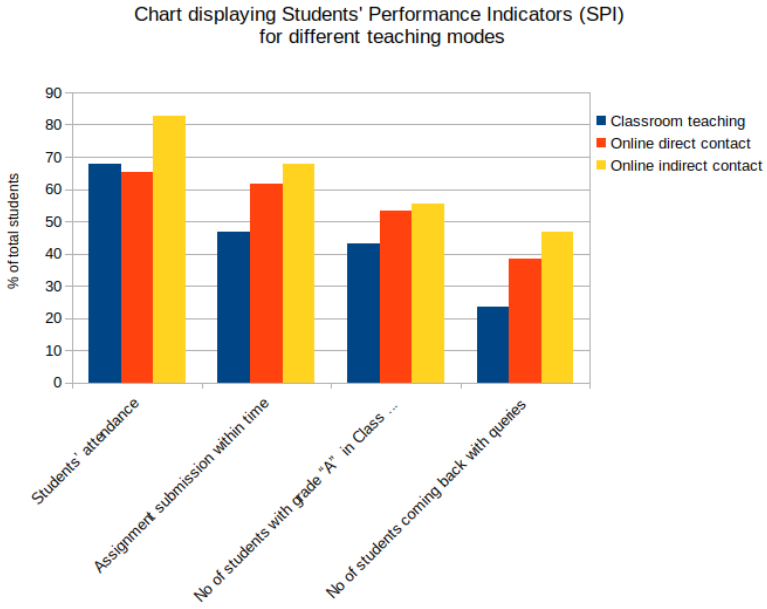

Figure 2: Students' Performance Indicator comparison for different teaching modes.

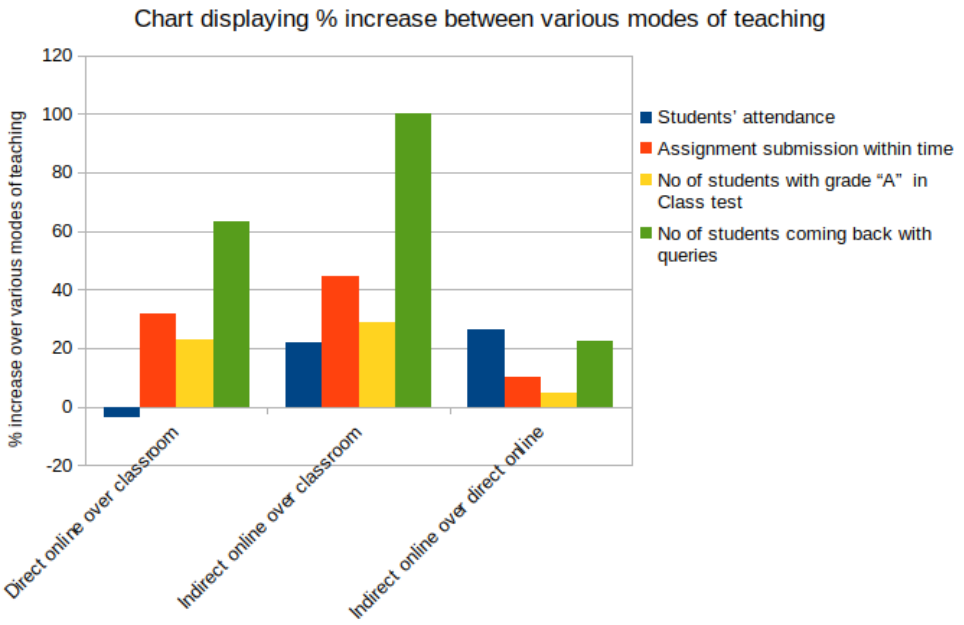

Figure 3: Comparison of percentage increase of SPI (Students' Performance Indicator) in online teaching over classroom-based teaching techniques.

TABLE 3: Table showing online class accessibility of the students

Online Class Accessibility	**% of total students**
Zero access	16.05
Difficult access	43.24
Easy access	40.7

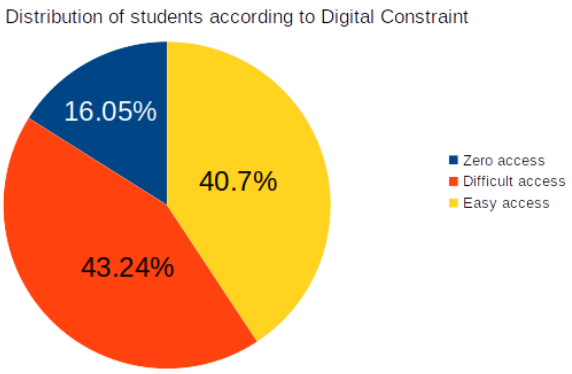

Figure 4: Distribution of population size of three groups having zero, difficult and easy access to online class facilities.

4.2 Observation

i) **Higher SPI for online platform:** From figure 2, it is evident that in all the sections, students' performance and response have gone up sharply when we shifted to the online platform, the only exception being the attendance of the students. Students have participated more in classroom teaching compared to the online teaching via direct contact mode, that is using Zoom, Skype etc video conferencing tools. Except this, the query of the students regarding class, the assignment submission and class test grades have all improved when the lecture is delivered in the online platform.

ii) **Easy and Difficult access group both are improving:** The size of easy access group is only 40.7% (Figure 4 and Table 3). Now Table 2 shows that all the SPI except "% of students coming back with queries for Direct Online mode teaching" are much greater than the size of easy access group. Therefore it is clear that SPI is improving for all those students having access to online classes: regardless of the degree of their Digital Constraint.

iii) Figure 3 compares three types of teaching more prominently by showing the percentage increase of online teaching over classroom teaching for all the SPI. It is clear that:

a) Both direct and indirect online class have significant percentage increase over classroom teaching in all sectors of class performance. Only the student attendance in direct online class is lesser than the classroom teaching otherwise the online platform has shown mush higher efficiency than the traditional classroom teaching.

b) **Absence is due to Digital Constraint:** According to figure 4, 16.05% of the total strengh has zero access to online facilities. Now, in table 2, 82.7% students have attended online class by indirect interaction. This means the absent students are 17.3% of the total strength. This indicates that, the students absent in the online class are absent due to lack of digital infrastructure. All those students who have any access to online class are attending the classes positively.

c) **Indirect Interaction mode as an excellent medium:** The indirect interaction based online class has appeared as an excellent medium of education since it has huge percentage increase over all other teaching modes with respect to all indicators: the students' attendance is higher by 21.8% than the usual classroom lecture and 26.4% higher than the online class by direct interaction. Students have performed better in the class tests after attending classes in the indirect mode of online teaching. 28.6% more students have obtained grade 'A' compared to the classroom teaching and compared to the online teaching by direct mode, 4.7% more students have obtained grade 'A'.

d) **Increased Class Queries:** More students are encouraged to ask questions in the online mode. The percentage increase in significant. Even some of the most shy ones are coming up with queries regarding the lectures delivered. Compared to the classroom teaching, there is as much as 100% increase in the number of students who are coming back with conceptual questions after attending online classes via indirect mode.

All the above observations can be explained if we study the advantages and disadvantages of the different teaching modes from a student's point of view as delineated in the following sections.

4.3 Classroom based teaching: Space and Time constraint

a) Traditional Classroom based teaching has space and time constraints. Students need to travel and be present at a particular place at a particular time. While this promotes the idea of a teamwork, group study and punctuality, in the semi-urban and rural area this might become very problematic. Transport options may be unsuitable, the bus fare might weigh heavily on the students who come from humble background. Some students in our group of respondents come from such a remote area that it is impossible for them to attend early morning classes. If it is a rainy weather, road conditions in many area renders a student unable to come and attend the class. Some students help their family in various jobs to boost the family income. Again, the health issue may become vital for a student who is travelling for 1.5 hours to come to the college or does some part-time job after attending the college. This is the main reason which affects the attendance in traditional classroom based teaching.

b) Since much time is spent in travelling to and from college, students become exhausted and get less time to devote for studies and assignments.

c) The space constraint is totally removed in the online class. Hence, online class saves much time and energy of the students which they can utilize in their studies and assignments.

4.4 Class Interaction

a) Social and Academic interaction:

Classroom teaching offers social and academic interactions between teachers and students, which is conducive to the realization of full potential of a student (Hamre et al (2007) and La Paro et al (2004)). Also it offers an active campus life which helps develop and sustain the community feelings and learning motivation (Rovai et al (2005), Saveney (2005), Donlevy (2003)). This is inevitable for a comprehensive learning of the lesson. In order to preserve this unique feature of classroom teaching in the online classes as well, in our study, the teacher-student ratio has been maintained at 1:20, following the analysis of Koc, N. And celik, B. (2015) regarding effect of class size on academic performance of the students. A small class size enables the teacher to devote enough time to explain the queries of the students and keep track of the progress and participation of each individual. The student-student interaction and group study has also been encouraged by giving them group assignments. This explains the fact that in spite of lower attendance, the online teaching by direct interaction shows higher "A" graders and higher assignment submissions than that in the traditional teaching learning process. The indirect interaction mode shows even higher efficiency in this regard.

b) Increased students' response/queries in online class:

In classroom-based teaching, usually students ask questions in the class. There are very few students who contact after class hours to clear doubts. Many students feel shy or awkward to go to the teacher and ask a question. However, in online classes, since the used platform is online itself, students have much less hesitation to drop a question to the teacher in the chat box or in the WhatsApp. In the indirect mode, personal contact is the only option for the students to clear their doubts. So, those students feeling awkward to ask question publicly, feel free to express their doubts personally. Hence the huge percentage increase in this category according to Table 2 and Figure 2 & 3. Needless to mention, a small class size is more required in online classes due to the increased class response and class queries.

4.5 Online Class Accessibility

Why is it that the attendance is smaller in direct interaction online method or the online teaching by indirect interaction is showing the best performance of the students? This can be explained by Table 3 and figure 4. The accessibility to the online class is not same for all. 16.1% of the total students have absolutely no infrastructure to attend the online class. Out of the remaining ones, almost half of the students ("Difficult Access" group) face the following difficulties while attending video conferences:

a) Very poor data connection: Server is lost in the middle of the class or video streaming is poor during class. Parts of lecture is lost for the student.

b) Have to borrow smartphone from another person: The device may not be available at the scheduled class hour. Therefore, online classes by direct interaction is beneficial for the "Easy Access" group only. For the "Difficult Access" group, which constitutes 43.2% of the total strength, online classes by indirect interaction is more useful. Indirect interaction lifts the time constraint by providing recorded lectures and study materials in pdf or word format which can be accessed anytime according to the data or device availability of the student. The students are able to follow everything even after attending to inevitable jobs at home. We have to remember that this survey has been done during a pandemic where regular life and livelihood of the population have been hit hardly and students as well are having a difficult time. So if the time constraint can be removed, their performance will improve even more. Particularly this has been done in the online teaching by indirect interaction. They are interacting later at suitable time over telephone. Figure 1 shows that online class by indirect interaction has least number of constraints among all three teaching modes considered.

This explains why online classes by indirect interaction has become so popular and is producing maximum benefits among all.

4.6 Effects of Lockdown

Lockdown has reduced the option of spending time in outdoor activities. However, it is difficult to say whether this is responsible for the improved performance of the students, because, the virtual world is still open to them for spending as much time there.

4.7 Laboratory-based subject

Laboratory work cannot be carried out in this mode except the Programming Lab. This is one huge drawback of this system.

4.8 Students' Feedback

In order to cross verify our argument, the students who attended online class were asked to give number to the three modes of teaching out of 5 according as:
very poor=1, poor=2, moderate=3, good=4 and very good=5

The percentage of the students along with corresponding marks given to the teaching modes is presented in the following table (Table 4):

TABLE 4: Students' Feedback regarding three modes of teaching

Teaching modes	Very poor	Poor	Moderate	Good	Very good
Classroom teaching	4.2%	4.2%	12.5%	33.3%	45.8%
Direct online	0	16.7%	70.8%	8.3%	4.2%
Indirect online	0	16.7%	41.7%	12.5%	29.2%

There is a clear shift in the pattern of marks given by the students to the different modes of teaching (Figure 5).

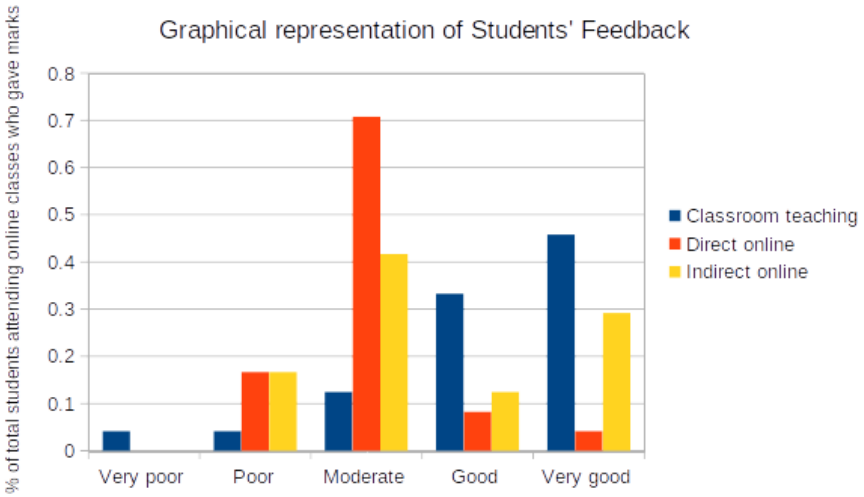

Figure 5: Students' feedback for three modes of teaching.

The significance can be understood quantitatively if the weighted average marks are calculated for three different teaching modes as follows:
1. Classroom teaching: 4.123 (out of 5)
2. Online teaching by direct mode: 3.00 (out of 5)
3. Online teaching by indirect mode: 3.55 (out of 5)
It is interesting to note:

a) **Classroom teaching most favourite or least favourite?**

4.2% students have given a "very poor" rating to the traditional classroom teaching whereas 45.8% students has given it a "very good" rating. Classroom teaching has got both "very good" and "very poor" rating from largest fraction of the students.

b) **Indirect interaction mode more useful for the students than a virtual classroom?**

Online teaching by indirect interaction, where matter is explained by a recorded video has got higher marks than that by direct interaction where direct video conferencing between the teacher and the students is being used. This is in spite of the fact that, direct interaction mode offers a virtual classroom environment that is closest to that of a real classroom and classroom teaching has got highest score among all three modes. Direct interaction mode, theoretically, should have been more popular.

c) **Students' favourite teaching mode has worst output**

Although classroom teaching has got highest score (4.123 out of 5) from the students, the students' performance in all sectors (except the class attendance in direct online mode) is worst in classroom teaching mode.
To understand the paradox, we asked the students to write down what type of problems they are facing in the different teaching modes:

1. **Difficult access group:**

51.5% of the students giving feedback reported that they have weak internet connection and have to borrow smartphone from somebody else. Therefore, they are not properly able to attend online classes conducted by Zoom or Skype video call. Server is lost in the middle of a class and most of the times the video quality of the video conference call is very poor. These students have been termed as having "difficult access" to online class in Table 3 and Figure 4 (the group size there is 43.24% as "zero access" students are included in that data set).

2. **Space and Time constraint of classroom teaching makes it unpopular:**
4.2% of the students having online facilities stay in remote area and/or are involved in part-time jobs to support their family. So they find it hard to travel and attend classes in college on a regular basis. For them, online classes have been an easy solution and they are attending classes regularly.

3. I**ndirect mode more popular than Direct mode:**
Recorded video lectures can be viewed any time. At odd hours, the data connectivity becomes better. Also, as the lecture is recorded, even if the strength of data fluctuates, the students do not miss anything. So indirect method of online classes have got higher marks than the direct method of online class.

4. **Students with good data speed prefer Direct online class:**
A fraction of the students who have easy access to online classes with good data connectivity have unequivocally given the direct online class 4 marks (8.3%) and 5 marks (4.2%). However, some others have complained about lack of practical classes which, indeed, is a matter of concern.

5. **Classroom teaching is most popular: The Digital Constraint and The Board work Constraint**
Figure 1 clearly shows the constraints of online teaching: the digital constraint. Figure 4 shows that 43.24% students have difficulty in accessing online facilities and 16.05% students are absolutely unable to attend any online class (although these students have not been included in the feedback collection). There is one more constraint: the board work constraint. Right now, a proper board work infrastructure suitable for online class as well as required skill to handle them is totally unavailable to the teachers who have been teaching in schools and colleges till date. In this work too the board work was carried out by writing on the Whiteboards provided in video calling apps and "Openboard" software with fingertips (in case of smartphone) and mouse (in case of laptop), which is far from what is required for a proper lecture delivery. All these constraints explain why, in spite of better academic performance of the students, classroom teaching is still most popular medium as per students' feedback who are able to attend courses in both modes: online and classroom-based. Figure 6 depicts the interplay of various constraints for three different teaching modes.

5. CONCLUSION

Based on the above results and discussion, we can come to the conclusion that, an efficient and sustainable teaching-learning process depends on a proper optimization of all the constraints depicted in figure 6 so as to ensure fluid exchange of ideas and concepts between the teacher and the students and also among the students themselves.

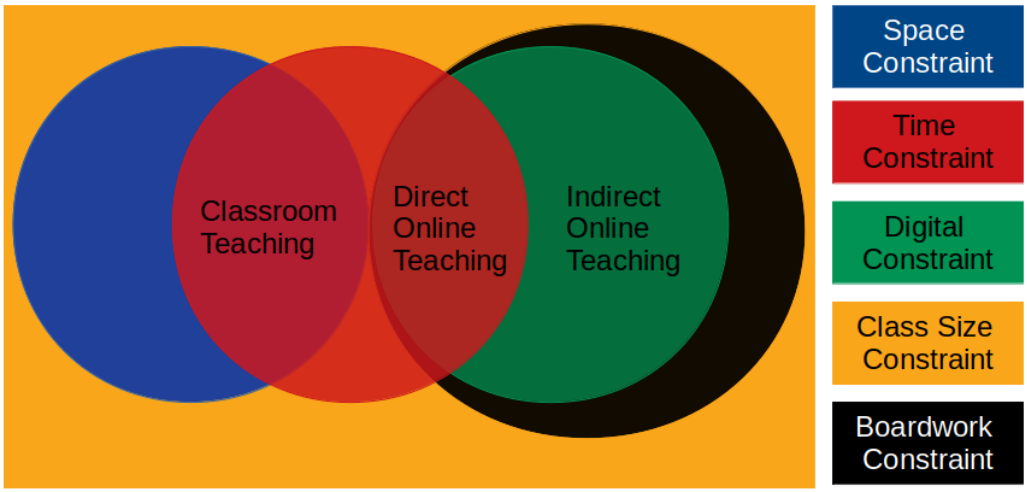

Figure 6: Interplay of different constraints dominating different teaching modes.

At present, infrastructure for online teaching is heavily lacking in India. 'board work constraint' and 'digital constraint' being two major barriers. But our study indicates that, in spite of infrastructural deficiencies, students are performing better in online platforms due to removal of space and time constraints of traditional classroom teaching. If online teaching-learning infrastructure and skill enhancement training is provided to the students' community as well as to the educators, a well-judged combination of direct and indirect mode of online teaching can be of great help to the students. The students will be able to attend the classes of a teacher regardless of his or her geographical location. The burden of hostel fees or room rents or the barrier of family approval for staying away from home for educational purposes can thus be totally removed. Also, in a densely populated country like India, going back to the traditional classroom-based teaching sessions will be difficult if corona virus threat does not subside sufficiently. As a whole, given adequate infrastructural back-up, online teaching-learning process is capable of ushering in a new era of education where globalization of human resources will definitely become a reality.

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