COVID-19 Pandemic is an Eye-Opener for Academicians to Use the Technology in the Teaching–Learning Process

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Abstract
Few things exist in life from the beginning but you don’t realize until they become a habit. Education is also one of those things which cannot be exempted from this. The lockdown forced most of the academicians to take some determining decisions and new interests to revamp the teaching–learning process. The objective of this study is to analyze the impact of technology in teaching–learning process before and after a pandemic. This analysis is done by statistical tests using paired t-test and z-test by collecting data from students and teachers. Results show that this pandemic is an eye-opener for academicians to use the technology in teaching–learning process.

Keywords
COVID-19, technology-enabled learning, eye-opener for academicians, online education

Introduction
The year 2020 has been a great challenge for people from all walks of life. It has altered and changed the lifestyle of every single human being. This year has introduced a new
dimension to our lives. We have understood the importance of the advancement of technology and its necessity (Castro et al., 2020).

The global impact of COVID-19, the disease caused by the novel coronavirus, intended that the education sector has to be ready for facing the heat of massive changes or rather setbacks. The world is grappling with an invisible enemy, trying to understand how to live with the threat posed by a virus (Marinoni et al., 2020). It is disappointing when we realize in the minds of many, COVID-19 is just another life-threatening hazard in a city that stumbles from one crisis to another. This pandemic has resulted in a major impact on the education sector.

Education is the most fundamental idea that persists in our society; which should never be compromised at any cost. Education is the reason for our progress. It is the sharing of knowledge from one generation to the other. If there is a hindrance to education even for a short period it is going to lead to a drastic effect (Alvi & Gupta, 2020). Hence for the above-stated reason, the education sector in the year 2020 had to make certain crucial decisions, such as adapting and evolving its teaching strategies (Shahzad et al., 2020). Although the experts were against the idea of teaching through online methods, the results proved otherwise. There is no doubt that personal interaction in a classroom environment is the best way to educate young minds, but the online methods have expanded the horizon for the students as well as the academicians (Demuyakor, 2020).

Now, during this pandemic situation due to COVID-19, all the students and teachers are stranded in their homes, and everyone is forced to shift to online learning although only 11% of Indian students prefer online college if not for the given situation (Mulenga & Marbán, 2020). This situation has given academicians no choice but to use the technology extensively in the process.

Although it was hard to switch from chalk and talk and to the usage of software tools, the benefits are way far ahead of the drawbacks. Tools that teachers lacked during classroom sessions were available with just a click of a button (Mishra et al., 2020). This not only aided the teacher but also helped the students to grasp complex concepts with ease.

As the old proverb says, “Necessity is the mother of invention,” has proven again to be true yet another time. After the evolution of this new method of the teaching–learning process, the frontiers have widened. The limitations that were present in the classrooms have now been reduced. Academicians were forced to adapt to creative and interactive methods in their sessions to facilitate their students who were hundreds of miles away. Various websites and graphic tools made physics and math easier to comprehend. Online meeting portals brought every student closer to the teacher. The gradient of back and frontbenchers was eradicated, everyone had to participate. These small variations and differences in the class proved to have a great positive effect (Teräs et al., 2020).

This pandemic has helped us move towards blended learning. New ways of delivery and assessment of learning opened immerse opportunities for a major transformation in the area of curriculum development and pedagogy. This is a great opportunity for
companies that have been developing and strengthening learning management systems for use of educational institutes.

During the offline teaching–learning process teachers were enforced to set question papers for tests and take as many copies depending on the number of students and the students were supposed to answer them in papers as well. Moreover, the paper correction process was time consuming and tedious one as well.

Opposed to that, now students were given both objective and subjective type tests online with the help of improved software to prevent any malpractices, and get their results almost instantly. This not only provides students with the opportunity to correct themselves while their answers were still fresh in mind or save a huge chunk of the teacher’s time spent on a paper correction but also is environment friendly as the unnecessary use of paper is avoided (Toquero, 2020). This is an important aspect that should be considered as climate change throughout the world is rapid and the only way to slacken the process is to choose eco-friendly methods as much as possible.

During offline classes, most students tend to feel uncomfortable to clear their doubts during class or reaching out to the teachers but online classes provide the students with an opportunity to clear their doubts one on one with their teachers via various portals.

Worldwide exposure—educators are getting opportunities to interact with peers around the world. Learners have indeed adapted to an international community. Students can manage time more efficiently due to online learning in most cases. The government has taken steps such as introducing apps like e-Pathshala, Swayam, Diksha for students of classes 1–12. MHRD served to be useful in departing requirements needed for online learning (Jena, 2020).

In this current situation, a lot of changes has already been done, for example, in Gmeet whose upper limit of participants was 30 before the pandemic has been updated to make it as 100 and new updates such as jam boards are being introduced too to make the teaching–learning process better and suitable for the current situation.

What else can be done when the situation goes back to normalcy to integrate the pros of online classes while the teachers and students meet in person in an educational atmosphere because as Bill Gates said “Technology is just a tool in getting the kids to work together and motivating them, the teacher and the learning atmosphere is the most important.”

E-learning is affordable only to the middle and higher socio-economic classes (Adnan & Anwar, 2020). The lower division of the society struggled to gain access to education and continues to do so. The Government started a channel to telecast recordings of the subject materials taught by teachers even then, there is a lag in passing down the lock, stock, and barrel of knowledge to students.

A large number of Indian students who were enrolled in foreign universities were forced to leave those countries. On an average scale, the fees paid for foreign education are hefty, students are devastated at the fact that they have to continue learning virtually and the large sum of money spent has gone vain. The lack of exposure, access to grade 1 facilities, and last but not least the experience has gone in for a toss.
If not for the pandemic, final year students would have traveled to new places for their internships and later would have been awaiting their placements. Unfortunately today all of that remains a dream for many. Especially in the IT sector, firms are unable to pay their existing employees due to lack of projects and the crisis, hence salary packages and employment of final year students have not been up to the mark of, and for many others, and it’s still a question mark.

Practical applications of different equipment are very hard to be understood with not having access to laboratories. House surgeons and medical practitioners are losing out the most due to a lack of hands-on experience (Gallo & Trompetto, 2020). Exposure to blue light and radiation from computers affects eyesight and could lead to major issues such as photophobia, migraine, and even eye cancer due to damage of the retina. It also leads to insomnia (Unni, 2020).

The social life of students has been tarnished and has been confined to four walls (Unni, 2020). Teachers and students were unprepared for e-learning. The sudden transition left most of them confused which ended in improper delivery of information. When we analyze we do realize that the benefits of online learning are way past its drawbacks. This untimed yet successful leap taken by the education sector will continue to expand even after the end of this terrible pandemic. Academicians will now involve sophisticated tools with ease for the pupils’ better understanding (Korkmaz & Toraman, 2020).

Although the pandemic was truly a curse in all of our lives, we have learned important lessons and have stepped out of our comfort zones. We have widened our frontiers and expanded our knowledge. The virus at a scale of 50–200 nm has connected teachers and students over thousands of kilometers. It has opened our eyes and has prepared us for the next thousands of years to come.

The objective of this research work is to analyze students’ performance, the present, and future of Technology Enabled Learning, and the impact of technology in the Teaching–Learning Process. Experiments are conducted by getting questionnaires from students and faculty members and results are passed on to statistical tests and inferences are reported.

This paper is organized as follows. Section “Literature Survey” highlights the review of related work. The problem statement is explained in section “Problem Statement” and section “Result and Discussions” gives the statistical analysis of the result. Section “Conclusion” gives the concluding remarks and summarizes the results.

**Literature Survey**

The COVID-19 pandemic has become a global health issue and has changed the teaching–learning process to a great extent (Hebebci et al., 2020). Most academicians are unaware of the technology and tools behind the teaching–learning process before the outbreak of the COVID-19 pandemic. Even though distance education methodology was in existence, only the course materials like e-books/PPTs/Question Banks were distributed in digital form. But they have not used any technology effectively
in this distance education methodology. Learning Assessment was also done offline which was not effective.

But due to this pandemic educators are forced to go for the online teaching/learning process. Now they are in a situation to search for effective tools for online teaching/learning and started to learn and use these tools. They started realizing that distributing materials in digital form alone is not only sufficient for an effective teaching–learning process. Many people have started to research the impact of online teaching among students and society (Shahzad et al., 2020). A survey has been conducted to analyze the advantages and disadvantages of online learning. Many researchers highlighted the impact of online learning. Online teaching–learning in higher education during the lockdown period is also have been analyzed (Alvi & Gupta, 2020). Online learning has created some health issues and social effects amongst the student community (Shah et al., 2020). The impact of online learning in teaching mathematics education (Castro et al., 2020; Mulenga & Marbán, 2020), health education, and language teaching has also been analyzed. Post-pandemic educational practice will be effective if educators use the technology during the offline teaching process (Teräs et al., 2020). Educators feel that the use of technology has improved not only their teaching but also has improved students learning. We strongly believe that this pandemic is an eye-opener for academicians. The findings of this study also confirm that it is an eye-opener for academicians.

**Problem Statement**

The COVID-19 pandemic changed traditional classroom education to an online mode. In this period, academicians and students are forced to use modern technology. The teaching–learning process is mainly focused on students’ learning (Crittenden et al., 2019), student engagement (Schindler et al., 2017), course content delivery (Ellis & Bliuc, 2019), LMS (Chaw & Tang, 2018), and student assessment (Shepard, 2019). The objective of this study is to analyze the role of technology in the above-listed factors to provide effective online teaching, online assessment, and the continuation of the same in the postpandemic period. To meet the objective, a statistical study was conducted based on a questionnaire, addressing the following research questions:

- Does technology help in the improvement of the academic performances of students?
- Is the improvement in student collaborative learning is significant due to increased usage of technology in the COVID-19 period?
- Are you in favor of a technology-enabled learning environment?
- Does technology help in the improvement of teaching methodologies?
- Will you use a learning management system in the future?
- Which e-learning resource is having more limitations?
- Whether course outcome target level is achieved in the COVID-19 period?
Methodology

The questionnaire of categories I and II are given to students, category IV is given to teachers, and categories III, V, and VI are given to both teachers and students. Category VII is based on the available data of online learning of students during the COVID-19 pandemic. The participants were college students studying undergraduates and postgraduate students. Totally 525 students participated in the survey. Also, 45 teachers participated in this survey. The questionnaire was posted in Google forms, category-wise. The link was sent to teachers and students of various colleges which are distributed geographically and the responses were received.

Result and Discussions

Hypothesis Testing on Academic Performance

To statistically validate the significant difference in the academic performance of students before and after using a technology-based learning management system, CGPA of semester exams of students before and after lockdown are collected and a paired t-test is conducted using the sample size (N = 525). In paired t-test, the null hypothesis is set as

\[ H_0: \text{There is no significant difference in the academic performances of college students before and after using a technology-based learning management system.} \]

\[ H_a: \text{There is a significant difference in the academic performances of college students before and after using a technology-based learning management system.} \]

The statistical results for the academic performance of college students are shown in Table 1. t-Statistic is calculated using the following equation:

\[ t = \frac{\bar{X}_D - \mu_D}{S_D / \sqrt{n}} \]  

(1)

| Table 1. Statistics for the Academic Performance of Students. |
|-----------------|---|---|---|
| Academic performance before using technology-based learning management system | 525 | 7.09 | 0.57 | 0.033 |
| Academic performance after using technology-based learning management system | 525 | 7.68 | 0.75 | 0.038 |
| Difference | 525 | 0.59 | 1.02 | 0.044 |
The \( t \)-statistic is computed and compared with the \( t \)-value at a 95% confidence level. As computed \( t \)-statistic 13.47 is greater than the \( t \)-value at 95% confidence level which is 1.6478. Hence the inference of the test is, there is a significant improvement in the academic performance of college students after using a technology-based learning management system.

**Hypothesis Testing on Collaborative Learning**

Statistical tests are performed to find whether there is a significant improvement in students’ collaborative learning due to increased usage of technology in the COVID-19 period. As a part of the internal assessment, students are evaluated based on group assignments, team projects, and laboratory worksheets. The total marks obtained in all these components are converted as a single mark out of 100%. During the COVID-19 period, students do the above-mentioned tasks using communication software like Google Meet, Microsoft Team, Zoom, etc. Communication technology plays a major role in the knowledge share, collaborative learning of students. The marks obtained by the students before the COVID-19 period which has not had much exposure to communication software and marks obtained during the COVID-19 period which has the exposure to technology were considered. The total number of students considered was 525. Since the same sample is used we have used the statistical test, namely, paired \( t \)-test. The null hypothesis and alternate hypothesis for paired \( t \)-test are given as follows:

\[ H_0: \text{There is no significant difference in the collaborative learning of college students before and after using technology.} \]
\[ H_a: \text{There is a significant difference in the collaborative learning of college students before and after using technology.} \]

The statistical results for collaborative learning of college students are shown in Table 2.

Based on the information provided, the significance level is 0.05, and the degree of freedom is 524. The critical value for the one-sided test is 1.6478. We have considered a one-sided test since we are interested in finding an increase in performance in a positive direction. Since \(|t| = 9.88595901 > 1.6478\), we discard our assumption. Hence the

| Table 2. Statistics for Collaborative Learning of Students. |
|-----------------------------------------------------------|
| N       | Mean    | Variance | SE  |
|---------|---------|----------|-----|
| Collaborative learning before using technology | 525     | 67.37    | 266.887 | 0.713 |
| Collaborative learning after using technology    | 525     | 76.047   | 226.713 | 0.657 |
| Difference                        | 525     | 0.674    | 404.193 | 0.877 |
inference of the test is, there is a significant improvement in the collaborative learning of college students after using technology.

**Hypothesis Testing on Support for Technology-Enabled Learning**

The objective of this research question is to find whether students and teachers are in favor of a technology-enabled learning environment. The questionnaire with yes/no type is given to all students and teachers and a total of 570 participants provided their responses. Since the questionnaire is of yes/no, the *z*-test for the single-population proportion test was performed. The proportion in favor of using a technology-enabled learning environment is fixed as 0.7. The summary of the statistical results is as follows.

The sample size is $N = 570$, the number of favorable cases for technology-enabled learning environment $X = 498$, and the sample proportion is $p = .8737$, with significance level .05, conjunction $p \leq .7$, and disjunction: $p > .7$.

This corresponds to the upper test, for which a *z*-test for one population proportion needs to be used. The critical value for the upper test is decided as $z_c = 1.64$ and the rejection region is $R = \{z: z > 1.64\}$.

The *z*-test result is computed as follows:

$$z = \frac{\bar{p} - p_0}{\sqrt{p_0(1 - p_0)/n}} = \frac{0.8737 - 0.7}{\sqrt{0.7(1 - 0.7)/570}} = 9.049$$

Since it is observed that $z = 9.049 > z_c = 1.64$, it is concluded that the conjunction is rejected. Therefore, there is enough evidence to claim that the population proportion $p$ is greater than $p_0$, at a .05 significance level. Based on a 95% confidence interval for $p$, (.846 < $p$ < .901), the graphical view is shown in Figure 1.

**Hypothesis Testing on the Improvement of Teaching Methodology Using Technology**

The objective of this research question is to find whether technology helps in the improvement of teaching methodologies. The questionnaire with yes/no is given to the teacher with a sample size of 45. The objective is to check the results of the survey with an expected population proportion of greater than 70% who will use technology for the improvement of teaching methodologies. *z*-Test for one population proportion test was performed. The population proportion in favor of using a technology-enabled learning environment is fixed as 0.7.

With sample size is $N = 45$, the number of favorable cases for technology-enabled learning environment $X = 38$, the sample proportion $p = .8444$, the significance level, $\alpha = 0.05$, conjunction $p \leq .7$, and disjunction $p > .7$ are to be tested. This corresponds to the upper test, for which a *z*-test for one population proportion needs to be used.
The critical value for the upper test is 1.64, the rejection region for this upper test is \( R = \{ z: z > 1.64 \} \) and computation of the \( z \)-test is as follows:

\[
z = \frac{\hat{p} - p_0}{\sqrt{p_0(1 - p_0)/n}} = \frac{0.8444 - 0.7}{\sqrt{0.7(1 - 0.7)/45}} = 2.114
\]

Since it is observed that \( z = 2.114 > z_c = 1.64 \), it is concluded that the conjunction is rejected. Therefore, there is enough evidence to claim that the population proportion \( p \) is greater than \( p_0 \), at a .05 significance level. Based on a 95\% confidence interval for \( p, (.739 < p < .95) \), the graphical view is shown in Figure 2.

**Hypothesis Testing on Future of LMS**

The objective of this research question is to find whether students and teachers will use the learning management system in the future, that is, the post-COVID-19 period. The questionnaire with yes/no is given to the teacher with a sample size of 570. The objective is to check the results of the survey with an expected population proportion of greater than 70\% who will use learning management systems in the future. \( z \)-Test for one population proportion test was performed. A hypothesized population proportion in favor of using a learning management system is fixed as 0.7. The summary of the statistical results is as follows.
The sample size is $N = 570$, the number of favorable cases for technology-enabled learning environment $X = 536$, the sample proportion is $p = .9404$, the significance level $\alpha = .05$, conjunction $p \leq .7$, and disjunction $p > .7$ are to be tested. This corresponds to the upper test, for which a $z$-test for one population proportion needs to be used. The critical value for the upper test is 1.64. The rejection region for this upper test is $R = \{z: z > 1.64\}$ and the computation for the $z$-test is as follows:

$$z = \frac{\hat{p} - p_0}{\sqrt{p_0(1 - p_0)/n}} = \frac{0.9404 - 0.7}{\sqrt{0.7(1 - 0.7)/570}} = 12.522$$

Since it is observed that $z = 12.522 > z_{c} = 1.64$, it is concluded that the conjunction is rejected. Therefore, there is enough evidence to claim that the population proportion $p$ is greater than $p_0$, at a .05 significance level. Based on a 95% confidence interval for $p$, $(.921 < p < .96)$, the graphical view is shown in Figure 3.

**Hypothesis Testing on Limitations on e-Learning Resource**

The objective of this research question is to find which e-learning resource is having more limitations. The e-learning resources required to access online classes, to take assessment tests, collaborative learning are Internet connectivity, Internet speed, Hardware configuration, devices (computers/laptops/phone/...
Figure 3. z-Test results for the usage of technology postpandemic.

Table 3. Users Perspective on Limitations of e-Learning Resources.

| Users  | Internet connectivity | Internet speed | Hardware configuration | Devices | Total |
|--------|-----------------------|----------------|-----------------------|---------|-------|
| Students | 190                   | 171            | 109                   | 100     | 570   |

Figure 4. Graph representation of users perspective of e-learning resources.
The questionnaire was given to both students and teachers and they have to identify any one of the resources as the most limited resource. The total number of participants was 570 and their responses were collected. The data collection is shown in Table 3.

The distribution of e-learning resources is shown in Figure 4.

From the above graph, we observed that internet connectivity is a major resource limitation. To verify statistically a binomial test with confidence intervals is done and the results are as follows:

The exact binomial p-value is 0 and the probability of observed proportion is $\frac{190}{570} = 0.33$ comes from a population not equal to 0.25 is >99.99% and the confidence interval is (29.58%, 37.31%). Thus from the experiment, the inference is a more limited resource is internet connectivity. Hence internet connectivity should be given at most priority and it should be addressed for the successful implementation of online learning in the post-COVID-19 era.

| Course code & course title | Course outcome | CO target level |
|----------------------------|----------------|-----------------|
| 15XW31 Discrete Structures  | CO1 78.11       | 70              |
|                            | CO2 77.72       | 70              |
|                            | CO3 79.37       | 70              |
|                            | CO4 71          | 70              |
|                            | CO5 70          | 70              |
| 15XW52 DBMS                 | CO1 72.06       | 70              |
|                            | CO2 73.23       | 70              |
|                            | CO3 76.6        | 70              |
|                            | CO4 70.64       | 70              |
|                            | CO5 73.98       | 70              |
| 15XW53 Transform Techniques | CO1 85.25       | 70              |
|                            | CO2 74.45       | 70              |
|                            | CO3 81.62       | 70              |
|                            | CO4 79.29       | 70              |
|                            | CO5 76.22       | 70              |
| 15XW54 Advanced Data Structures | CO1 83.57    | 70              |
|                            | CO2 70.98       | 70              |
|                            | CO3 70.9        | 70              |
|                            | CO4 75.71       | 70              |
|                            | CO5 70.97       | 70              |
| 15XW35 Microprocessor Systems and Programming | CO1 69.79 | 70 |
|                            | CO2 71.58       | 70              |
|                            | CO3 83.77       | 70              |
|                            | CO4 88.12       | 70              |
|                            | CO5 88.42       | 70              |
The objective of this research question is to find whether the course outcome target level is achieved in the COVID-19 period. During this COVID-19 period starting from June 2020 to October 2020, the courses taught online are considered. These courses are conducted using a learning management system including e-assessment tools. For each course, there are five course outcomes (COs) and the target outcome is fixed as 70%. Also, the actual course outcome achieved data is collected and shown in Table 4.

The graphical results of the above data are shown in Figure 5. From the graph, we can conclude that all courses have achieved the target course outcome.

**Conclusion**

This lockdown has been productive for most of the academicians with comprehensive involvement to learn technology and use the technology extensively in the process. As Albert Einstein said, “It is the supreme art of the teacher to awaken joy in creative expression and knowledge.” The use of modern technology has truly helped the teachers to awaken joy in learning, amongst their students.

A detailed study to find the impact of COVID-19 in education was performed. The teaching Learning process can be classified as pre, during, and post-COVID-19 era. The use of technology in the pre-COVID-19 eras is limited and the conventional classroom techniques were followed. The COVID-19 pandemic created an opportunity for change in the teaching–learning process and forced the stakeholders to use technology. With the help of technology, the stakeholders have more flexibility to improve the teaching–learning process. The objective of this study is to bring out the role of technology during the pandemic and the continuance of the same in post-pandemic.
First, our statistical findings proved that technology played a major role in education. Second, there is a significant improvement in students’ collaborative learning with the advent of the usage of technology. Third, students and teachers are in favor of a technology-enabled learning environment during as well as post-pandemic. Our findings stress the importance of internet connectivity for the continuation of technology-enabled education. COVID-19 has proved that the technology innovations have been helping in managing the pandemic in a timely, systematic, and calm manner, which has indeed revolutionized the workplace of academicians.

Limitations

This study was conducted in a homogenous group of students in the computer science stream. The study has to be extended including a heterogamous group of students, to analyze the impact of technology in the teaching-learning process for the entire student community. The other limitations are the small sample size and non-random selection of the students and teachers participants. However, the major advantage of this work is that both students’ and teachers’ perspectives are considered to attain the conclusion.

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