

Student's Performance through Online and Offline in core Information Technology courses: A Comparison

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Abstract—Online based education was enforced during the COVID-19 pandemic to minimize interruption in the pedagogy of teaching. Impact of transition from face-to-face to online based education on students' learning needs to be studied. This research aims to compare the continuous assessment performance of students in both gmeet-based online and traditional offline classroom methods. Data required for this study was obtained from an academic institution (TCE-Madurai). Three core courses namely Database Management System (IV semester), Web Programming (V semester), and Theory of Computation (III semester) in the Department of Information Technology for both online (2018-2022 batch and 2019-2023 batch) and offline (2017-2021 batch) approach has been compared while considering the same cohort. Each course is designed with Course Outcomes (COs). We did Extrapolative analysis, Descriptive analysis, Correlation analysis, Regression analysis, ANOVA, and MANOVA analysis to find the relationship between internal assessments and terminal examination. The dataset has been collected from 337 students' from the 2018-22 batch and 134 students from 2017-21 batch in the B.Tech program. Internal assessment includes three continuous assessment tests (CATs) and three assignments marks mapped with respect to corresponding COs. Terminal exam marks were also considered in the study. The dataset contains various features like scores of individual students in both internal assessments and terminal exams. Regression analysis helped to derive the relationship between final exam score which includes a specific course, a specific student, and a specific mode of delivery - Online / Offline. It explained the relationship between final exam score and internal assessment marks. It is observed that the students in online mode had significantly higher scores for the majority of the Course Outcomes, mainly at the Knowledge level. It is difficult to measure certain areas like students' skills and attitude level such as students' peer Engagement, Human Interaction, Communication/Preparation, Critical thinking, and Team skills in online mode.

Keywords—Regression analysis, ANOVA, MANOVA, Online Vs Offline, Core courses, Performance, Internal test, Terminal exam,

I. INTRODUCTION

Learning organizations like Primary & secondary schools, Engineering, Arts, law and medical colleges, and universities in India have switched back to conventional (face-to-face) lecture

mode for Teaching and Learning Process (TLP) in a classroom, although many academicians from state and central universities have also started blended learning along with regular classes in classroom.

The impact of COVID-19 has caused the closure of Higher Secondary Schools and Engineering education across the nation. Worldwide, around 1.2 billion students are out of the traditional classroom lectures (Ahmed Elzainy et al., 2020). As a result, the teaching and learning process has transformed noticeably, with the drastic inclination of digital learning platforms, whereby TLP is undertaken remotely and on online mode.

The pandemic has changed the entire educational sector and forced all academics and students to switch to digital mode of teaching and learning process suddenly. Educators adopted innovative approaches to handle TLP, Assessment methodology, and Course Outcomes attainments. A lot of Learning Management Systems (LMS) and ICT Tools are used by schools and college teachers to post course lecture materials, conduct online mode exams and formative assessments (Jaclyn Broadbent et al, 2021). Both faculty members and students utilized and managed online live-streaming teaching effectively. Even though the traditional method of learning has positive and powerful aspects in improving the quality of teaching, but the situation changed the whole scenario. A lot of challenges were faced by teachers and students initially, but later they adopted Online Teaching learning Management systems reasonably well.

In various countries, educational institutions suffered a lot and students are not able to continue their education due to continuous lockdown. Many Health organization sectors and psychiatrist reported mental illness among students. These situations create a need for online classes irrespective of learning domain across the country and need to save youth's mental attitude.

This sudden change is difficult to adopt by both students and faculty members from educational institutions, in terms of pedagogical approach, content delivery, and assessment pattern in TLP. This research paper studies the efficacy of students learning through online learning and compares it with conventional classes particularly in B.Tech Information Technology courses like Theory of Computations, and

Database Management Systems, and Web Programming.

II. RESEARCH MOTIVATION AND BACKGROUND

In the traditional face-to-face class, the students can have social interaction with peer students and direct interaction with faculty members. Their doubts can be clarified then and there in the classroom itself. They have the freedom to participate in many technical events organized by professional societies and industrial interactions. This in turn develops their cognitive skills from lower level to higher level. They can also undergo group projects in the laboratory which helps them to experience real-time applications. In conventional classes, students can have three assignments and three Continuous Assessments Tests (CAT). They can answer descriptive answers and handle problem solving. The blooms level starts from the remembering level and goes up to the understanding, applying, and analyzing level. So actual learning happens in the conventional classroom. (Bowman et al., 2014) and (Buttner and Black 2014) found that online lectures helped students and (Chow, 2015), (Dodson, 2014), (Babaali and Gonzalez (2015), (Woolley 2015) and (Callahan 2016) found no significant difference between digital mode and offline mode of learning.

On the other hand, the online mode of learning has no direct interaction with teachers, peer students, or friends (Joel Trussell et al, 2020). There is no social interaction between them. The students are sitting in front of computers from the morning to the evening. Even though there are an adaptability and comfort of online classes, Internet connectivity issues in rural and panchayat division is a challenge for both Higher Secondary School (HSS) and college students to make use of digital mode (Muthuprasad et al., 2021). The students lack real-time experience in the laboratory. They find it difficult to solve tutorial problems. They have three assignments and three continuous assessment tests, the level of all questions asked are in lower levels, i.e., students are answering mainly multiple-choice questions. So real learning is not fully happening among all students. Even though they are scoring good or high marks in the assessment test, they cannot think of solutions to the higher order of blooms level like analyze and evaluate with corresponding Program Outcomes PO4- Critical thinking problems. The students using online classes performed multiple-choice questions rather than solving quantitative problems. The student's knowledge level, skill level, and attitude levels cannot be measured completely.

The main objective of this research paper is

1. To find suitable relationships and correlation among various assessments, both in offline and online modes of teaching.
2. To study the impact of mode of teaching on various assessments.

III. STUDY DESIGN

This study was conducted in Tier 1- Thiagarajar College of Engineering, Madurai, India. We have chosen three core

courses - Database Management Systems, Theory of computation, and Web Programming in Information Technology. The study data constitutes the participation of 337 students from the III, IV, and V semesters of different sections of the B.Tech program in both Online and Offline mode.

Following are the research questions (RQ) that the study attempts to answer:

RQ1: What impact do online teaching-Learning practices have on core courses?

RQ2: How effective is the correlation among various assessments with respect to Course Outcomes in both Online and Offline modes of teaching?

IV. EXPERIMENTAL RESULTS AND DISCUSSION

The online and offline data for three engineering courses (Theory of Computations, Web systems, and Databases) were obtained. All courses are of three credits. The total duration to cover the syllabus in both online and offline mode are 36 hours. The data contains various features like scores of individual students in both internal assessments and terminal exams. These scores are distributed based on various Course Outcomes (CO), for both the internal assessments and the terminal exam.

The methodology of analyzing the given data follows:

1. Pre-processing of data: The art of pre-processing is to identify Null or missing data and handle them appropriately. Data duplication was also validated. Mismatch of values due to wrong scores were identified using the maximum value after normalization. This is possible, when a score greater than the allowed maximum value is entered for a specific student.
2. Normalization of data scores: In terminal assessments, the total score was divided among various COs, instead of obtaining them individually. In contrast, internal assessments have data for each CO individually. Normalization was done to make the process of comparison easier. Here, various elements of an assessments like Assignment -I, II, III, and CAT I, II, and III, and COs are considered and studied for the impact of outliers.
3. Understand the underlying statistics of the given data: Data distribution differences among different assessments were studied using exploratory data analysis through boxplot. Appropriate boxplots are drawn for both internal assessments and final exam, as per individual Course Outcome (COs). Comparing the median, Interquartile Distance, and the outliers provide us with some insights into how students have performed in the assessments. From the boxplots, skewness, and kurtosis of the given data are also studied.
4. Homogeneity of variances (Homoscedasticity): In order to verify whether the variances among different samples or groups are equal or not, Bartlett's test was used. If heteroscedasticity is present, then parametric

tests can be applied.

5. Descriptive analysis is provided for the given assessments in terms of mean and standard deviation or standard error. Using these statistical parameters, decisions about how the students' performance varies in the online and offline study are obtained.
6. Correlation analysis: Correlation was obtained among different COs in internal assessments. Additionally, these internal COs were correlated with the final assessment.
7. ANOVA: ANOVA test is used to study with the presence of different factors, online and offline mode of teaching, whether the mean of the dependent variable differs or not. Various dependent variables are considered individually. Various internal assessment COs and final assessment are considered as dependent variables.
8. MANOVA: MANOVA considers multiple response or dependent variables with different groups or factors. Here, various dependent variables are grouped for online and offline modes of teaching.
9. Regression analysis: The relationship between the dependent variable (terminal assessment score) and independent variables (various internal assessments scores) is performed using Ordinary Least Squares Regression (OLS), which is similar to linear regression model regression. OLS model is used to minimize the sum of square differences between the observed and predicted values. Along with individual variables, interaction terms of individual internal assessments within themselves and with the mode of teaching are considered.

The final exam score is considered as the dependent variable with the mean final score, affect of the mode of delivery, individual class scores, and interaction between mobility and courses as independent variables. Regression could also be done with regards to the relationship between final exam score and the homework or internal assessment scores.

A. Online Vs Offline data analysis - Web

Dataset: We collected the dataset from the student participants to investigate the performance of core courses in both online and offline mode to analyze the impact of online in TLP. The dataset is taken from three core courses of B.Tech Information Technology across various semesters-III, IV, and V from different class students. Dataset comprises of both online and offline marks with students' internal (three assignment marks and three Continuous Assessment Test) and Terminal exam with respect to five COs. We have taken the study from 2017-2021 as an offline batch and 2018- 2022 as an online batch. From the third semester, we had taken Theory of computation course, around 45 students from 2018-2022 batch who have attended in online mode and 2017-2021 batch who have attended in offline mode. For the Web programming course, about 68

students from the 2018-2022 batch and 67 students from 2017-2021 were considered as the dataset.

We implemented our experiment in google colab environment. The pre-processed data is used for normalization which plays an important role in Data analysis. In our dataset, except register number, name, and offline column, other columns are normalized using a technique called `df_max_scaled()`.

We did Extrapolative analysis, Descriptive analysis, Correlation analysis, Regression analysis, ANOVA, and MANOVA analysis to find the relationship between internal assessments and terminal examination for all three courses. Here we have explained the outcome of the Web Programming course in detail.

Data distribution differences among different assessments in web programming for offline, online, and combination of offline and online were illustrated using boxplot in figure 1. X-axis represents normalized score and Y-axis represents internal and Terminal total of COs. Visualization technique is more important. Comparing the median, Interquartile Distance, and the outliers provide us with some insights on how students have performed in the web programming online and offline assessments. From the boxplots, skewness, and kurtosis of the given data are also studied.

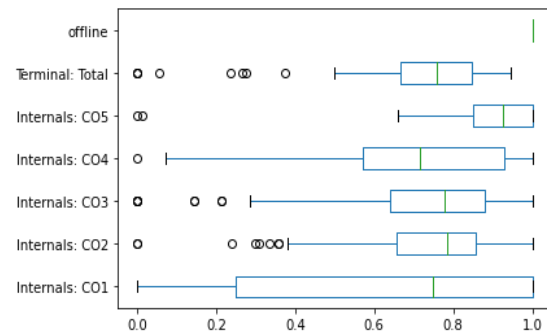


FIGURE I-A
BOXPLOT FOR WEB PROGRAMMING-OFFLINE

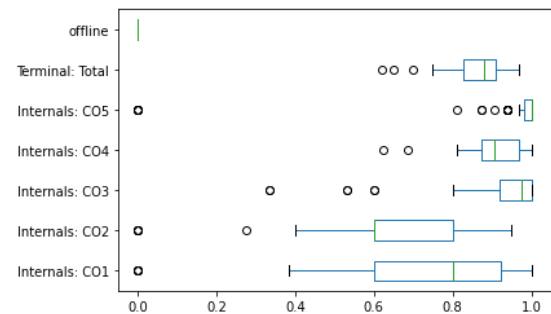


FIGURE I-B
BOXPLOT FOR WEB PROGRAMMING-ONLINE

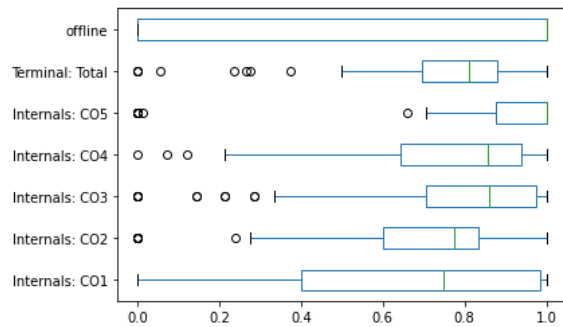


FIGURE 1-C
BOXPLOT FOR WEB PROGRAMMING-OFFLINE AND ONLINE

Figure 1-A shows the boxplot for the offline dataset. The figure shows that except CO1, all students in both internal assessment and terminal exam secured more than 60% in all COs. Many outliers are visible in CO2, CO3, and Terminal Total. CO1 is the lowest median in internal assessment. The mean value of CO5 achieved 90%. Whereas in the Online mode shown in Figure 1-B, except CO1 and CO2, students secured 80% and above in both internal and terminal exams. Figure 1-C shows the boxplot visualization for both offline and online modes. Except for CO1, the result of all COs is ranked greater than 70%. Students got good marks in the higher level of COs.

Tables 1, 2, and 3 display descriptive analysis such as count, mean, standard deviations, min, 25%, 50%, and 75% quartile, max, standard error of the mean, skewness, and kurtosis values contained in every feature in offline mode dataset, online mode and combination of both modalities. 134 students' records have been taken from the offline dataset and 203 students' records from the online dataset. Skewness is used to measure symmetry; if the skewness value is greater than +1.0, the distribution is right-skewed otherwise it is left-skewed. In table 1-Offline dataset, except CO1 and CO4, all COs and Terminal are in right-skewed. In table 2- Online dataset, all COs, and Terminal are in right-skewed. And for kurtosis, if the value is greater than +1.0, then the distribution is called leptokurtic, otherwise, it is called platykurtic.

TABLE 1
DESCRIPTIVE ANALYSIS OF WEB – OFFLINE DATASET

Param	In-CO 1	In CO 2	Int CO3	Int CO4	Int CO5	Ter min al	Offli ne
Count	134.00	134.00	134.00	134.00	134.00	134.00	134.0
Mean	0.577425	0.746655	0.718185	0.708472	0.902482	0.717724	1.0
Std	0.388327	0.198469	0.231878	0.221631	0.140427	0.181645	0.0
Min	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0
25%	0.2500	0.657775	0.640000	0.571400	0.850000	0.666230	1.0
50%	0.7500	0.7857	0.7778	0.7143	0.9268	0.757040	1.0
75%	1.0000	0.8571	0.8800	0.9286	1.0000	0.846580	1.0
max	1.0000	1.00	1.0000	1.0000	1.0000	0.94	1.0

		00			0	49	
Std err of mean	0.033546	0.017145	0.020031	0.019146	0.012131	0.015692	0.0
skew	-0.403254	-1.186544	-1.360759	-0.640009	-4.028724	-2.070360	0.0
Kurtosis	-1.366975	2.016938	1.563413	0.239139	23.392613	5.448295	0.0

TABLE 2
DESCRIPTIVE ANALYSIS OF ONLINE MODE DATASET

Param	In-CO1	In CO2	Int CO3	Int CO4	Int CO5	Ter min al	Offli ne
Count	68.0000	68.0000	68.0000	68.0000	68.0000	68.0000	68.0
Mean	0.709391	0.629044	0.923519	0.917807	0.911997	0.862500	0.0
Std	0.257754	0.219379	0.149477	0.070919	0.261288	0.070083	0.0
Min	0.00000	0.00000	0.33330	0.62500	0.00000	0.62000	0.0
25%	0.600000	0.600000	0.919725	0.87500	0.98050	0.82750	0.0
50%	0.8000	0.60000	0.9750	0.9063	1.0000	0.8800	0.0
75%	0.9231	0.8000	1.0000	0.9688	1.0000	0.9100	0.0
max	1.0000	0.9500	1.0000	1.0000	1.0000	0.9700	0.0
Std err of mean	0.031257	0.026604	0.018127	0.00860	0.031686	0.008499	0.0
skew	-1.202506	-1.222561	-2.705232	-1.4684	-3.240336	-1.254913	0.0
Kurtosis	1.245145	1.994557	7.093332	4.15284	8.985987	1.950711	0.0

TABLE 3
DESCRIPTIVE ANALYSIS OF BOTH OFFLINE AND ONLINE MODE DATASET

Param	In-CO 1	In CO2	Int CO3	Int CO4	Int CO5	Ter min al	Offli ne
Count	203.0	203.0	2.3	203	203	203	203
Mean	0.6237	0.708	0.788	0.780	0.906	0.767	0.660
Std	0.354	0.213	0.229	0.209	0.188	0.168	0.474
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25%	0.40	0.60	0.705	0.642	0.878	0.695	0.00
50%	0.750	0.773	0.860	0.857	1.00	0.81	1.00
75%	0.984	0.833	0.975	0.937	1.00	0.88	1.00
max	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Std err of mean	0.024	0.014	0.010	0.014	0.013	0.011	0.033
skew	-0.67	-1.14	-1.148	-1.12	-3.83	-2.27	-0.69
Kurtosis	-0.89	1.87	2.00	0.99	15.78	7.09	-1.55

RQ1: What impact do online teaching-Learning practices have on core courses? From Tables 1, 2, and 3, it is inferred that the impact of online teaching and learning practices achieve more scores compared to offline datasets. Then we

have conducted Bartlett's test homogeneity of variance for terminal score in both offline and online and homogeneity of variance between various internal assessments in offline and online mode. We checked the following condition: The score of p-value determines heteroscedasticity. With a p-value > 0.05, we assume the data as heteroscedastic.

After normalization, we have checked the correlation between every attribute in the dataset. We have conducted one way ANOVA test to study with the presence of different factors, online and offline mode of teaching, whether the mean of the dependent variable differs or not. With a p-value < 0.05, the mean value of the dependent variable like 'terminal total' is significantly different from the group.

MANOVA is also used to check whether the mean between two or more groups differ if you have multiple continuous response variables. Here, various independent variables are grouped for online and offline modes of teaching. Then regression analysis is done using the OLS regression model. Except for the name, register number, and terminal-total, all variables are considered as independent variables and Terminal total is the dependent variable. Apply linear OLS and train our model. Table 4 shows the OLS regression results of Regression analysis for the Web programming course.

TABLE 4
REGRESSION ANALYSIS FOR ONLINE AND OFFLINE DATASET

Dep.Variable	Y	R-Squared	0.989
Model	OLS	Adj.R-Squared	0.988
Method	Least squares	F-Statistic	776.2
Date	Sat, 28 Aug, 2021	Prob (F-Statistic)	4.55e-166
Time	11.19	Log-Likelihood	218.27
No.Observations	203	AIC	-394.5
Df Residuals	182	BIC	-325.0
Df Model	21		
Covariance Type	Nonrobust		

TABLE 5
INTERACTION BETWEEN WITHIN AND OTHER COs

	Coef	Std err	t	P> t	[0.02 5]	[0.97 5]
Internals:CO1	0.7251	0.269	2.698	0.008	0.195	1.255
Internals: CO2	0.4918	0.451	1.091	0.277	-0.398	1.382
Internals:CO3	0.4401	0.547	0.804	0.422	-0.640	1.520
Internals: CO4	-0.0253	0.416	-0.061	0.951	-0.846	0.795
Internals: CO5	0.0347	0.236	0.147	0.884	-0.432	0.501
Offline	0.0296	0.063	0.471	0.0638	-0.094	0.365
Internals:CO1 :Internals:CO2	0.1459	0.111	1.315	0.190	-0.073	0.365
Internals: CO1: Internal:CO3	-0.1968	0.159	-1.238	0.217	-0.510	0.117
Internals:CO1: Internals:CO4	-0.0439	0.140	-0.313	0.755	-0.321	0.233
Internals: CO1: Internals:CO5	-0.5200	0.270	-1.926	0.056	-1.053	0.013
Internals: CO2: Internals:CO3	-0.1782	0.093	-1.918	0.057	-0.361	0.005
Internals:CO2: Internals:CO4	-0.4479	0.195	-2.294	0.023	-0.833	-0.063
Internals: CO2: Internals:CO5	-0.1680	0.283	-0.595	0.553	-0.726	0.390

Internals:CO3: Internals:CO4	0.0818	0.429	0.191	0.849	-0.764	0.928
Internals:CO3: Internals:CO5	-0.0886	0.124	-0.716	0.475	-0.333	0.156
Internals:CO4: Internal:CO5	0.1790	0.547	0.327	0.744	-0.900	1.258
Internals: CO1:offline	0.1790	0.547	0.327	0.744	-0.900	1.258
Internals:CO2: offline	0.1597	0.120	1.335	0.184	-0.076	0.396
Internals: CO3: offline	0.2137	0.438	0.488	0.626	-0.651	1.078
Internals:CO4: offline	0.1201	0.157	0.765	0.445	-0.190	0.430
Internals:CO5: offline	-0.1256	0.132	-0.953	0.342	-0.385	0.134

TABLE 6
CAPTION: POLYNOMIAL REGRESSION TRANSFORM

Omnibus	18.066	Durbin-Watson	1.856
Prob(Omnibus)	0.000	Jarque-Bera (JB)	25.437
Skew	-0.562	Prob (JB)	3.00e-06
Kurtosis	4.321	Cond.No	444

RQ2: How effective are the correlation among various assessments with respect to Course Outcomes in both Online and Offline? From Table 4- the regression analysis for online and offline datasets, it could be inferred that R-squared value is about 99.8%. The interactions among various assessments with respect to COs in both Online and offline are explained in table 5. Here, we adopted the OLS model for 203 records, the F-statistic value of about 776.2 describes the entire significance of a regression. From the above tabulation 5, it is evident that out of 203 students, their coefficients, standard error, t-value, $P > |t|$ explains the interaction between each course outcome and other course outcomes. Interactions between COs are implemented by Polynomial regression transform. The degree of the polynomial is used to control the number of features in the dataset. Table 5 inferred interactions between individual COs with other COs and measured coefficients, standard error, t, p, etc. If $P > |t| < 0.05$ then the model is better. But in table 5, except CO1 & interaction between CO1 and CO5, interactions between CO2 and CO3, interactions between CO2 and CO4, all $P > |t|$ values are greater than 0.05.

From tables 4, 5, and 6, we can understand the nature of the dataset, interactions effects i.e., multiple X (internal COs) variables have an interaction effect between them that influences Y (Terminal total) significantly more than the sum of its parts. Table 6 explains the Durbin Watson value as 1.856 and the Omnibus value as 18.066. The skewness value is less than 0.5 and kurtosis is about 4.321.

Table 7 inferred MANOVA results for the web online and offline. MANOVA tests show that whether or not the observations are randomly and independently sampled from the dataset. Each dependent variable – Internal CO1, CO2, CO5 has an interval measurement. MANOVA is used to find the covariance-variance between variables to test for the difference between COs.

Intercept	Value	Num DF	Den DF	F Value	Pr > F
Wilks' lambda	0.0585	6.0000	196.0000	526.1085	0.0000
Pillai's trace	0.9415	6.0000	196.0000	526.1085	0.0000
Hotelling-Lawley trace	16.1054	6.0000	196.0000	526.1085	0.0000
Roy's greatest root	16.1054	6.0000	196.0000	526.1085	0.0000

df_max_scaled["offline"]	Value	Num DF	Den DF	F Value	Pr > F
Wilks' lambda	0.5360	6.0000	196.0000	28.2760	0.0000
Pillai's trace	0.4640	6.0000	196.0000	28.2760	0.0000
Hotelling-Lawley trace	0.8656	6.0000	196.0000	28.2760	0.0000
Roy's greatest root	0.8656	6.0000	196.0000	28.2760	0.0000

TABLE 7
MANOVA- MULTIVARIATE LINEAR MODEL

CONCLUSION

This work presented the comparison of students' performance through online and offline learning in core Information Technology courses. Various comparisons using Extrapolative analysis, Descriptive analysis, Correlation analysis, Regression analysis, ANOVA, and MANOVA analysis have been made to study the impact of online teaching and learning practices in core courses.

From three core courses in Information Technology offered by both in conventional method-offline mode and online mode, there is an evidential difference between the students' performance in both internal assessments and terminal examinations scores. In offline mode, the weightage of COs is distributed as mentioned in the course. But in the terminal exam, COs are distributed equally. We noted that students in online mode had significantly higher scores for the majority of the Course Outcomes. Even though without social interaction, it is difficult to measure certain areas like: students peer Engagement, Human Interaction, Communication/Preparation, Critical thinking, and Team skills. It is suggested to adopt a discussion forum in LMS to improve peer engagement and human interactions. Through seminar presentations for Projects, we can improve communication and team skills. Use project-based experiential learning to improve student's Critical thinking. This research work revealed that the performance of students in online has created a higher impact in core courses than in offline through the results obtained from skewness, kurtosis, etc. The correlation among various assessments with respect to Course Outcomes in both Online and Offline is effectively measured with the help of regression, AVOVA, and MANOVA. In the future, we plan to consider the activity-based learning methodology and assessment pattern to measure the students' higher-order cognitive levels.

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