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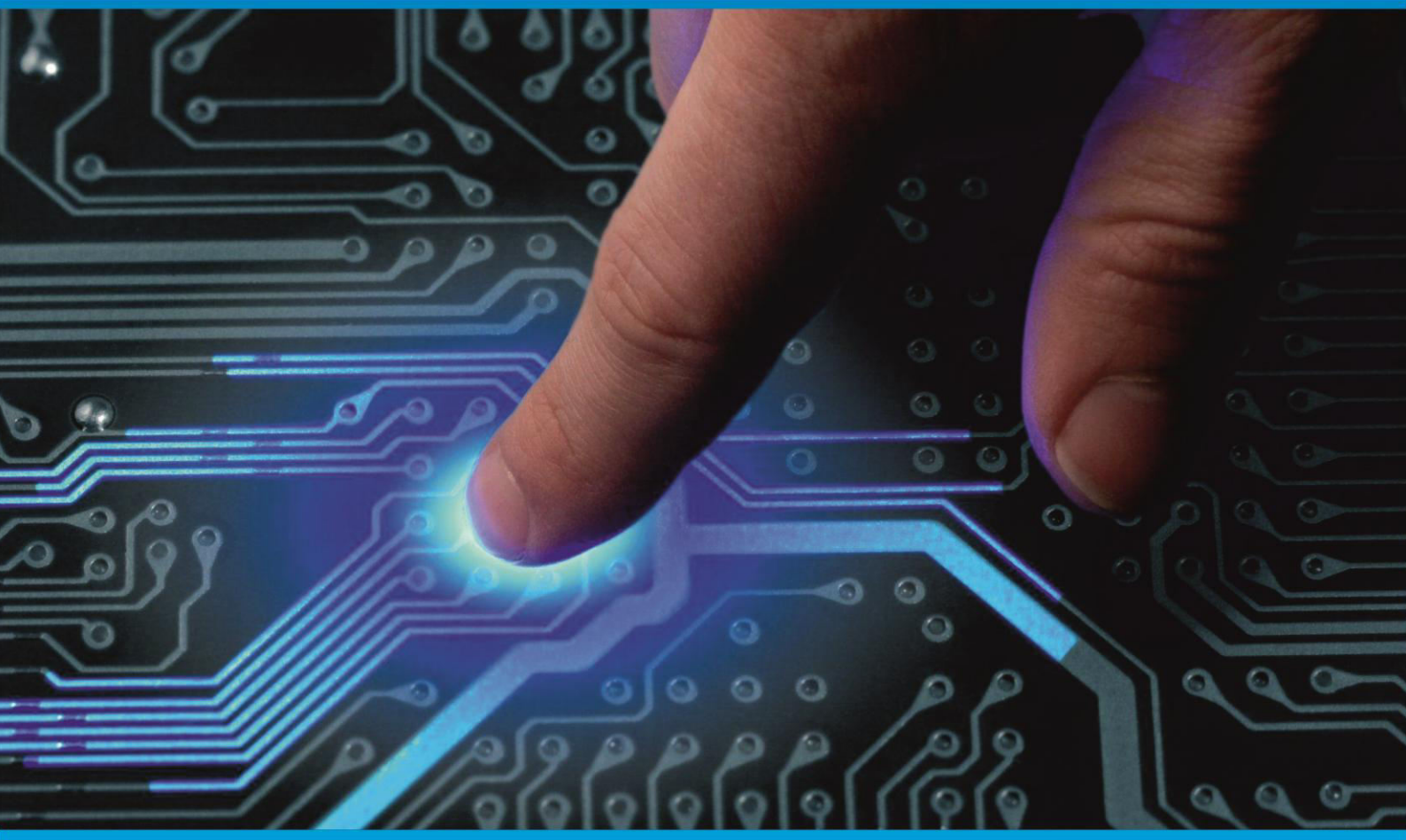

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A Statistical Approach to Study the Effect of Online Learning in Student's Academic Performance

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ABSTRACT: In recent years, with the development of Internet technology, e-learning has become an indispensable method and a new epitome which is broadly used and implemented by educational institutions around the world. This research work is a statistical approach to study the impact of online learning on students' academic performance and to measure the factors that affect the use of e-learning & its impact on students based on the availability and usage of various ICT tools by the students for educational purposes such as electronic devices, broadband network, Internet speed, websites and applications.Being a descriptive study, a self-administered questionnaire was created and under-graduate and graduate students that aged between 19-24 yearswere surveyed. By implementing simple random sampling, 100 samples were randomly selected for the study. Further, the sample was analyzed by using T-test,Z-test and Pearson's Correlation Coefficient in SPSS software. The key findings from this scrutiny show that the independent variables have great influence on the dependent variable.It was revealed that the mean score obtained by students having limited resourceswas fairly equal to those who were more privileged. Additionally, the difference between students' ICT usage was found significant at 0.01 levels in favor of those having high internet speed, greater source of connectivity, more number of ICT devices and those with good GPAs.

KEYWORDS: Simple random sampling, t-test, z-test, Pearson's correlation analysis,student's academic performance, ICT usage.

I. INTRODUCTION

Learning is a process of acquiring knowledge, performance and skills. Today, technology clearly makes our lives easier. It is considered as an important medium in many aspects of our lives, including academic learning. Delivery of education including the activities of teaching, learning and assessment through various electronic media is called online learning or E-learning. E-learning helps the learner to get knowledge at a distance through internet and enables one to learnanytime and anywhere. There are few essential things needed for this which indeed has become a necessity in today's generation. Internet and PC are a major part of our daily life now. Sharing our views, ideas and our lives through internet with other people has changed a lot in the way we leisure, work or study. Online learning has received much attention this year globally as a consequence of COVID-19 pandemic.

Survey questionnaire

A survey form was created in Google forms which consisted of 7 distinct questions:

1) Gender of student
2) What device(s) do you have? (Laptop, PC, Mobile, Tablet, Broadband Wi-Fi, Other)
3) How is the internet connectivity at your place? (Select 3 for 'High; 2 for 'Medium'; 1 for 'Low')
4) What is/are the source(s) of internet connection? (Mobile network, Broadband network)
5) How often do you use these following websites for educational purpose? (Google Search, Google Scholar, Research Gate, Science Direct, LinkedIn, Other)
6) How often do you use these platforms for learning purposes? (Google meet, Microsoft teams, Zoom, Other)
7) What is your CGPA? (Out of 10)

Data Collection

The study population for this research were the under graduate and graduate students ranging between 19-24 years. The link of the online survey form was shared among the students. There were 150 responses in just 2 days.

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Data Cleaning

This step was the most time consuming and challenging task to do. The survey taken contained categorical data which was further converted to numerical data by setting the criteria of giving points on the basis of their usage which was 2 if 'Always'; 1 if 'Sometimes'; 0 if 'Never'. The data in the gender column was converted into 1 if Male and 0 if Female (binary data). The possession of ICT devices and source of internet connectivity was also scored according to the check boxes selected. Also, there were responses of few students who did not take the survey seriously which resulted in an erroneous data. One respondent was apparently having a GPA of (1E+19). We removed the rows which would have affected the analysis with the help of excel spreadsheet functions.As a result, our population size reduced to N=135.

Sampling technique

Simple random sampling is a sampling method that uses random selection so that all the entries in the population have an equal probability of being chosen. We have applied simple random sampling method without replacement to ensure that we have an unbiased sample where each of the individual data occurs only once.

Steps in computing the size of sample:

I. Determining the size of population: N = 135

II. Decide margin of error: e = 5%

III. Use the formula:

$$n = \frac{N}{1 + N(e)^2}$$

$$n = \frac{135}{1 + 135(0.05)^2}$$

$$n = 100$$

IV. Sample proportion(%): $\frac{100}{135}$ i.e., 74%

The sampling was done using random number generator software and the generated sample (n = 100) was used for analyzing and experimenting by performing parametric tests.Prior to the study, informed verbal consent was obtained from each individual student. In regard to confidentiality, the participants were informed that the obtained information will not be made available for anyone who is not involved in the study and it will remain confidential for the purposes that intended for.

The research seeks to meet the following objectives:

i)Hypothesizing the difference in mean of the student's performance and test their significance with the independent variables.

ii) Finding if correlation is significant between the ICT usage by students and all the other independent variables.

II. LITERATURE SURVEY

A.R. Artino Jr. et. al[1] inspected the potential differences in self-regulation and learning motivation levels between undergraduates with n = 87 andpostgraduates with n = 107 when studying online. The research particularly conducted a comparative analysis of the motivational beliefs, engagement andintense processing strategies of college and graduate students. As assumed, the critical thinking level of the postgraduate students learning onlinewas higher than that of the college students. In addition, after controlling for differences in experience, logistic regression analysis exhibited that the membership of the graduate students was anticipated by a higher level of critical thinking and a lower level of procrastination whereas that of the undergraduates was predicted by substantial task value beliefs and intensions to take up the future online courses.

R.T.S Araujoet. al[2] proposed a goal in which they statistically evaluated the effectiveness of e-learning courses in engineering. In order to achieve the research purpose, the use of the analyzed learning resources was observed in the distance learning courses, and the evaluation tools were modified, verified and applied to students. In order to test the learning effect, the tool was analyzed using multivariate statistical methods, viz. Principal Component Analysis (PCA) and normative correlation analysis. The multivariate analysis with canonical correlations revealed how the two groups have made positive contributions from the PCA application.

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Emtinan Alqurashi[3]explored how online learning self-efficacy (OLSE), learner– instructor, learner– content and learner–learner interactions (LII, LCI, LLI) can predict perceived learning and student satisfaction. After surveying167 students, the results disclosed that the model with all four indicator factors was fundamentally prescient of perceived learning and fulfillment. The research found that LCI was the greatest and most notableindicator of student satisfaction, while OLSE was the greatest and most noteworthyindicator of perceived learning. However, LLI was not prescient of perceived learning and student satisfaction. This examination recommends that teachers utilize systems that improve students' OLSE, LII, and LCI.

Michal Bączeket. al[4] conducted a survey to investigate perception of online learning among medical students. E-learning was viewed as less efficient than face-to-face learning with regard to social competences and increasing skills. Students evaluated that they were less energetic during online classes as compared to regular classes (P<.001). Level of acceptance of online learning was analyzed using descriptive statistics. The nonparametric Wilcoxon signed-rank test was applied for comparing sentiments on online and face-to-face learning. Also, Mann-Whitney and Chi-square tests were used to compare answers between more and less advanced students.

Eddie M. Mulengaet. al[5] studied the online learning math activities of potential teachers during the COVID-19 pandemic. SPSS 24.0 software was utilized to analyze the data and K-means clustering analysis was applied to organize the data into clustering. A one-way analysis of variance was carried out in the cluster analysis tool to test the difference between the extents of online mathematics behavior of prospective teachers in the teaching of math activities. The results indicated that online learning math activities have significant mean difference in clustering. The second cluster had the best academic performance, which means that the students in that cluster had demonstrated excellent online mathematics learning skills in a high-tech environment.

Xu. D et. al[6]analyzed a dataset which contains near about 500,000 courses enrolled by more than 40,000 university students in Washington. The research examined students'adaptability to the online environment withrespect to their persistence and earninghighscores in online courses compared to their potential to do so in F2F courses. While a wide range of students in the study endured decrements in performance in online lessons, some battled more than others to adjust such as males, young students and students with average and below average scores. Overall, theoutcomessuggest that in order to improve student performance in online courses, colleges could take at least four distinct approaches: screening, scaffolding, early warning, and wholesale improvement.

Tuan Nguyen [7] investigates the evidence for the adequacy of e-learning by summarizing andorganizing the challenges and findings of e-learning as null, mixed, positive and negative. Special consideration is given to the meta-analysis on the viability of e-learning, the heterogeneous results of understudy learning and the internal problems of the choice of learning environment. Overall, there is well grounded evidence which implies that online learning is usually as effective as traditional forms. In addition, these documents indicate that researchers should go past the "no significant difference" circumstance and contemplate the next phase of online learning.

Sung Youl Park, etc. al [8] studied the factors that influence the acquisition and use of mobile learning by college students. A total of 288 students participated in this study from Konkuk University. By using linear structural relationship program (LISREL) and structural equation modeling technology, the process of students adopting m-learning is explained. The overall underlying model based on the technology acknowledgement model includes system accessibility, mobile learning self-efficacy, subjective norms (SN), relevance to students' majors (MR),attitude (AT),behavioral intention and perceived ease of use and usefulness to use mobile learning. The research results confirm the correctness of the model in explaining students' acceptance of mobile learning. M-Learning AT is the most important structure to explain the causal procedure in the model, succeeded by the students'SN and MR.

T. Muthuprasad et al. al [9] through an online survey of 307 students, focused on understanding the views and preferences of agricultural students on online learning. They explored the preference of the students for differentaspects of online courses, which will help design an efficient e-learning environment. The results showed that during the pandemic, most respondents (70%) were prepared to choose online courses to manage the curriculum. Most students tend to use smart phones for online learning. Through content analysis, they discovered that students favor a recording class with quizzes at the end to enhance their learning efficiency. Students believe that the flexibility and convenience of online classrooms make it an attractive option, while broadband connectivity issues in rural areas make it a challenge for students to take advantage of online learning programs. However, in many agricultural education systems where the

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curriculum is practice-oriented, it may not be fully converted to an online mode, and a hybrid mode is required. The insights in this article can help design courses in a different curriculum for the new normal.

S. Palviaet. al[10] recorded national factors affecting the quantity and quality of online education. These factors include national laws; industry; federal, state, and local governments; Internet technology dissemination; ICT capabilities; and income and digital divide. This editorial introduces the current status, trends and challenges in the field of online education in five regions of the world (South America, North America, Europe, Africa, Asia and Asia Pacific). This study describes the development of online education based on available technologies since the telegraph era, and provides implications for countries and world organizations concerning the same. It was further discussed that e-education is becoming more and more popular in almost all regions of the world, and will continue to exist worldwide.

III. PROPOSED SYSTEM APPROACH

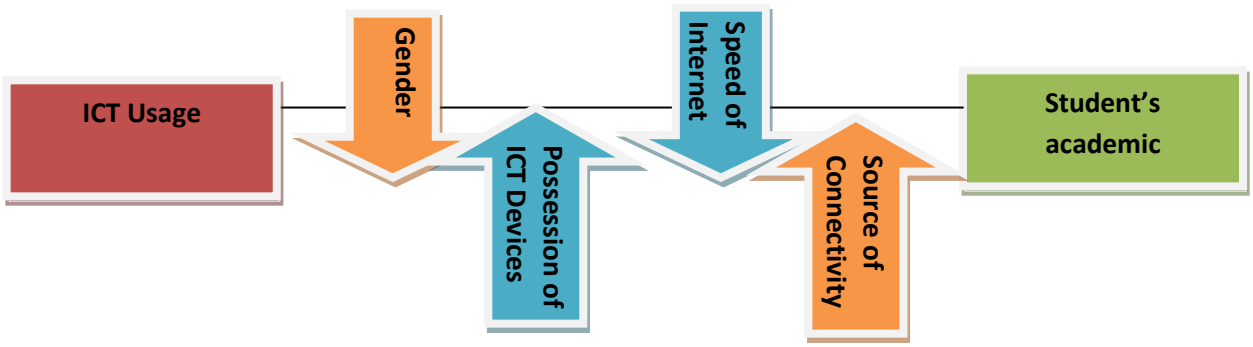

Fig1. Proposed research model

Figure (1) represents the research model where ICT usage and the students' academic performance (GPA) are the dependent variables (DV) and gender, possession of ICT devices, speed of internet and source of internet are the independent variables (IV). We have conducted a statistical approach in order to analyze our sample and find significance between the IVs and DVs. Based on the research model; the following hypotheses are developed for testing:

Null Hypothesis 1:There is no significant difference in the means between the students' score who have high internet connectivity and the students' score who have low internet connectivity.

i.e. $H_0: \mu_1 = \mu_2$

where μ_1: Mean of students' score having high internet connectivity

μ_2: Mean of students' score having low internet connectivity

Alternative Hypothesis: There is a significant difference in the means between the students' score who have high internet connectivity and the students' score who have low internet connectivity.

$H_1: \mu_1 \neq \mu_2$

Estimation of population parameter:

Internet connectivity	Count of students	Mean of GPAs	SDofGPAs
High	$n_1 = 29$	$\bar{X}_1 = 8.927$	$S_1 = 0.81$
Low	$n_2 = 29$	$\bar{X}_2 = 8.437$	$S_2 = 0.9$

Table1. Descriptive statistics of 1st hypothesis test

As each of the sample size is<30, we will perform T-test of significance for equality of 2 means for the hypothesis.

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Estimation of population variance:

$$S^2 = \frac{1}{n_1 + n_2 - 1}\left[\sum(X_1 - \bar{X}_1)^2 + \sum(X_2 - \bar{X}_2)^2\right]$$

$$S^2 = \frac{1}{29 + 29 - 1}[18.38 + 22.87]$$

$$S^2 = 0.723$$

Computing Standard Error:

$$\text{SE}\ (\text{X}_1 - \text{X}_2) = \sqrt{S^2\left(\frac{1}{\text{n1}} + \frac{1}{\text{n2}}\right)}$$

$$= \sqrt{0.723\left(\frac{1}{29} + \frac{1}{29}\right)}$$

$$\text{SE}\ (\text{X}_1 - \text{X}_2) = 0.223$$

Thus, the standard error of the sampling distribution of 2 means is 0.22.

Computing alpha (α):
We are working with a 95% confidence level.

$$\alpha = 1 - \frac{Confidencelevel}{100}$$

$$\alpha = 1 - \frac{95}{100}$$

$$\alpha = 0.05$$

At 5% level of significance ($\alpha = 0.05$) and degree of freedom ($dof = 57$), the critical value from the t-distribution table is 1.672.
Computing the margin of error (ME):

$$ME = Criticalvalue * Standarderror$$

$$ME = 1.672 * 0.223$$

$$ME = 0.373$$

Now,

$$t = \left|\frac{\bar{X}_1 - \bar{X}_2}{\sqrt{S^2\left(\frac{1}{\text{n1}} + \frac{1}{\text{n2}}\right)}}\right|$$

$$t = \left|\frac{\bar{X}_1 - \bar{X}_2}{SE}\right|$$

$$□ = \left|\frac{8.927 - 8.437}{0.223}\right|$$

$$□ = 2.197$$

We know that the critical value at 5% level of significance ($□ = 0.05$) and degree of freedom ($□_1 + □_2 - 1$) i.e., 57 from the t-distribution table is 1.672.
Therefore, $|□| > □_{0.05}$
We observe that the calculated t value is greater than the tabular t value. Hence, the hypothesis is rejected. This means that there is a significant difference in the means between the students's score who have high internet connectivity and the students' score who have low internet connectivity.
From this, we can conclude that the speed of internet connectivity has a significant effect instudents' academic performance in an online learning approach.
Null Hypothesis 2: There is no significant difference in the means between the students' score who possess >3 ICT devices and the students' score who possess <3 ICT devices.

i.e., $H_0: \mu_1 = \mu_2$

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where μ_1: Mean of students' score possessing >3 ICT devices
μ_2: Mean of students' score possessing <3 ICT devices
Alternative Hypothesis: There is a significant difference in the means between the students' score who possess >3 ICT devices and the students' score who possess <3 ICT devices.

$$H_1: \mu_1 \neq \mu_2$$

Estimation of population parameter:

Possession	Count of students	Mean of GPAs	SD of GPAs
>3	$\square_1 = 31$	$\bar{\square}_1 = 8.537$	$\square_1 = 0.843$
<3	$\square_2 = 34$	$\bar{\square}_2 = 8.675$	$\square_2 = 0.87$

Table2. Descriptive statistics of 2nd hypothesis test

As each of the sample size is >30, we will perform Z-test of significance for 2 means for this hypothesis.

Standard Error:

$$SE\ (X_1 - X_2) = \sqrt{\left(\frac{S_1^2}{n1} + \frac{S_2^2}{n2}\right)}$$

$$SE\ (X_1 - X_2) = \sqrt{\left(\frac{(0.843)^2}{31} + \frac{(0.87)^2}{34}\right)}$$

$$SE\ (X_1 - X_2) = 0.212$$

At 95% confidence level ($\alpha = 0.05$), the critical value from the z-distribution table is 1.96.

Margin of error:

$$ME = Criticalvalue * Standarderror$$

$$ME = 1.96 * 0.212$$

$$ME = 0.415$$

Now,

$$z = \left| \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\left(\frac{S_1^2}{n1} + \frac{S_2^2}{n2}\right)}} \right|$$

$$z = \left| \frac{\bar{X}_1 - \bar{X}_2}{SE} \right|$$

$$z = \left| \frac{8.537 - 8.675}{0.212} \right|$$

$$z = |-0.65|$$

$$z = 0.65$$

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At 95% confidence level ($\alpha = 0.05$), the critical value from the z-distribution table is 1.96.

Therefore, $|z| > z_{0.05}$

We observe that the calculated z value is smaller than the tabular z value. Hence, the hypothesis is accepted. This means that there is no significant difference in the means between the students' score who possess >3 ICT devices and the students' score who possess <3 ICT devices.
From this, we infer that the possession of ICT devices does not affect students' academic performance when learning in an online medium.
Similarly, we will carry out Z-tests for the following hypotheses:
Null Hypothesis 3: There is no significant difference in the means of academic performance between the students who have mobile data as a source of internet and the students who have broadband connection.

Source of data	Count of students	Mean of GPAs	SD of GPAs
Mobile data	$\square_1 = 35$	$\bar{\square}_1 = 8.584$	$\square_1 = 0.919$
Broadband connection	$\square_2 = 65$	$\bar{\square}_2 = 8.683$	$\square_2 = 0.874$

Table3. Descriptive statistics of 3rd hypothesis test

Based on the sample data, we estimate that there is no significant difference between the means between the students GPA who have mobile data and those having broadband connection. The standard error of the difference between 2 means i.e., SE $(X_1 - X_2)$ is 0.19. Given a 95% confidence level ($\square = 0.05$), the critical value from the z-distribution table is 1.96; the margin of error around that estimate is 0.37 and the result is not significant as the calculated value ($\square = 0.53$) was smaller than the critical value. As a result, we come to the conclusion that source of internet connection does not affect the students' performance.
Null Hypothesis 4:There is no significant difference in the means of academic performance between male and female students.

Gender	Count of students	Mean of GPAs	SD of GPAs
Male	$\square_1 = 54$	$\bar{\square}_1 = 8.629$	$\square_1 = 0.898$
Female	$\square_2 = 46$	$\bar{\square}_2 = 8.672$	$\square_2 = 0.883$

Table4. Descriptive statistics of 4th hypothesis test

As expected, we tested that there is no significant difference in the means between the GPAs of male and female students. In simple words, we can say that gender does not affect the students' academic performance.
By performing z and t tests, we measured if the difference between 2 sample means is significant. But, our research proposes more than that. In the next column, you must see a correlations table. We have applied Pearson's correlation coefficient test statistic using SPSS software to measure the statistical relationship between the IVs and DVs and to determine the direction and strength of the relationship.

IV. RESULTS AND OUTCOMES

Table (5) shows that the first hypothesis H_1 having a t-score of 2.19 greater than critical value is rejected while the other three hypothesis; H_2, H_3 and H_4 having a z-score smaller than the critical value ($t_{0.05}$=1.96) are accepted.

Relation	SE	ME	Critical value at α=0.05	Z/T score	Hypothesis
GPA + Speed of internet	0.223	0.373	1.67	t = 2.19	Rejected
GPA + Possession	0.212	0.415	1.96	z = 0.65	Accepted
GPA + Source of connectivity	0.189	0.37	1.96	z = 0.53	Accepted
GPA + Gender	0.177	0.347	1.96	z = 0.28	Accepted

Table5. Z/T-scores and hypotheses test

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From the hypothesis tests, we attained some inferences as stated below:
i) The speed of internet has a significant effect in students' academic performance. When learning online, the students are highly dependent on the internet if they want to attend lectures or make some extra notes form the educational websites. It is evident enough to say that having a good internet speed suggests a gradual increase of GPA.
ii) Possessing more number of ICT devices does not signify betterment of students' academic performance. The students who owned not more than 3 ICT devices performed as exceptionally as those who owned 4 or 5 devices. This shows that a student is not reliant on have greater facilities in order to perform satisfactorily in academics.
iii) Source of connectivity does not affect the students score. Surprisingly, this hypothesis did not detect any evidence making any effect to the relationship between the two variables. Considering the result of the first null hypothesis, we can also deduce that the speed of mobile data is as good as that of the broadband network which effectively meets the requirements of the students in an e-learning culture in today's generation.
iv) Gender has no effect on the academic performance. Evaluating some factors in terms of gender is unreasonable and the test proves the effect.
Secondly, we executed Pearson's correlation coefficient. The results as shown in table (5) tell us the significance in correlation between the independent and dependent variables. A positive coefficient says that the variables change together where as a negative coefficient says that there is an inverse correlation between the variables.

Correlations

		Gender	Possession of ICT devices	speed of internet connection	source	GPA	ICT usage
Gender	Pearson Correlation	1	0.029	0.105	0.016	-0.112	0.004
	Sig. (2-tailed)		0.773	0.297	0.878	0.267	0.966
	N	100	100	100	100	100	100
Possession of ICT devices	Pearson Correlation	0.029	1	.424**	.457**	0.173	.442**
	Sig. (2-tailed)	0.773		0.000	0.000	0.085	0.000
	N	100	100	100	100	100	100
speed of internet connection	Pearson Correlation	0.105	.424**	1	.284**	.326**	.760**
	Sig. (2-tailed)	0.297	0.000		0.004	0.002	0.000
	N	100	100	116	100	100	100
source	Pearson Correlation	0.016	.457**	.284**	1	0.118	.340**
	Sig. (2-tailed)	0.878	0.000	0.004		0.244	0.001
	N	100	100	100	100	100	100
GPA	Pearson Correlation	-0.112	0.173	.326**	0.118	1	.306**
	Sig. (2-tailed)	0.267	0.085	0.002	0.244		0.002
	N	100	100	100	100	100	100
ICT usage	Pearson Correlation	0.004	.442**	.760**	.340**	.306**	1
	Sig. (2-tailed)	0.966	0.000	0.000	0.001	0.002	
	N	100	100	100	100	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

Table6. SPSS annulated output table

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From the Pearson's correlation test, there were the following findings jotted down below:
i) ICT usage showed a significant positive correlation with all the independent variables except for gender variable at 0.01 level of significance. This indicates that possession of ICT devices, speed of internet, source of internet and GPA affects the usage of ICT by the students.
ii) There is a significant correlation between the GPA of students and the ICT usage by them as well as the speed of internet. This means that the ICT usage and internet connectivity has a positive effect on the students' performance.
iii) GPA and gender of students showed a negative insignificant correlation. This conveys that there no correlation between the two variables.

V. FUTURE SCOPE AND DISCUSSION

The experiments with real data are usually very time consuming and requires days to finish even a single test. Given a limited time and responses from the students, this research work has a high scope for improvement. Many different statistical tests can be performed based on the sampling distribution and the outcomes desired. Along with that, many more variables can be taken into effect so as to achieve more significant results and discover new variables that happens to have a high correlation with the dependent variables. The study has mainly focused on the student's performance and ICT usage leaving the research work with a scope for growth. With reference to the results of the parametric tests performed, we can improve them by attaining different sample size with more powerful attributes. The future work concerns in-depth analysis of the population, new proposals to try different model and simply curiosity. In addition, the respondents were new in using an online learning environment. Several factors such as lack of experience, varying student expectations etc. could have biased the present findings.

VI. CONCLUSION

The current study helps in understanding how possession of ICT devices, speed of internet and source of connection affect on e-learning and usage of ICT tools by the students. The focus of our research work was to examine the factors affecting student's academic performance in an online learning environment and the correlation between the ICT usage and other independent variables. The data was collected through an online survey by creating a Google form and distributing it among the college students. Three testes were effectuated: t-test for small samples, z-test for large samples and Pearson's correlation coefficient analysis to find significant correlations. By applying correlation test, many relations were found significant. The results also concluded that the speed of internet has a significant effect on the student's academic performance. This research with a real time dataset showed that the students have successfully adapted to online learning provided adequate amount of resources available.

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