QUALITY OF SERVICE METRICS MODEL FOR CLOUD COMPUTING APPLICATIONS AND SERVICES: EMPHASIS ON ONLINE LEARNING IN HIGHER EDUCATION SECTOR

A thesis submitted to the

University of Petroleum and Energy Studies

For the Award of
Doctor of Philosophy
in
Computer Science

BY

Jolly Upadhyaya

June 2019

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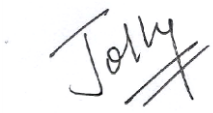
DECLARATION

I declare that the thesis entitled Quality of Service Metrics Model for Cloud Computing Applications and Services: Emphasis on Online Learning in Higher Education Sector has been prepared by me under the guidance of Prof. (Dr.) Neelu J. Ahuja, Professor & Head, Department of Systemics, School of Computer Science, UPES. No part of this thesis has formed the basis for the award of any degree or fellowship previously.



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DATE: 28 June, 2019

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THESIS COMPLETION CERTIFICATE

This is to certify that the thesis on **"Quality of Service Metrics Model for Cloud Computing Applications and Services: Emphasis on Online Learning in Higher Education"** by **Jolly Upadhyaya (SAP ID : 500014047)** in partial completion of the requirements for the award of the Degree of Doctor of Philosophy in Engineering from University of Petroleum and Energy Studies (UPES), Dehradun is an original work carried out by her under our joint supervision and guidance.

It is certified that the work has not been submitted anywhere else for the award of any other diploma or degree of this or any other University.

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DEDICATION

I dedicate this Thesis to my late father Sh. Sudhir Kumar Upadhyaya who has been my source of inspiration and strength when I thought of giving up, and my mother Mrs. Veena Upadhyaya, who has continually provided me moral, spiritual, and emotional support.

ABSTRACT

The study presented in this thesis was conducted under the premise to effectively understand the QoS dimensions needed to enhance the experience of CC users towards excellence by users of Indian higher education. This study was important to critically understand higher education population needs and existing GAPS in QoS for Cloud Computing (CC) as to get the best and effective QoS from the educational provider that manages CC architecture. It included users who are defined as students and/ or faculty, enrolled as undergraduate, graduate or postgraduate in different Educational Institutions across geographic locations. Cloud Computing is primarily based on the fact that it provides fast access to educational services and resources with high performance and support. At the same time, diverse factors like lack of institutional budgets, concerns for cyber security, and cost of technical and computer support, continue to impact educational administration decision while adopting this enriched CC service.

Literature review on the topic led to the inference that on one hand several research projects have been directed to understand and enhance the QoS of CC, however, limited focus has been directed towards understanding QoS from higher education and e-learning users' perspective. Majority of the studies have emphasized on the technical issues of cloud computing or the issues of CC security. The present work identifies the gaps in QoS expected by the academic CC user for their scientific study in higher education and the service quality they actually experience. These gaps result in dissatisfaction among the CC academic user for they are not able to utilize the vast dimensions of technology which they should be getting as higher education students or/and faculty to enhance their skills and knowledge. In the current work, which has been also published by the scholar, evaluation was directed

to understand QoS of CC services that academic users expect while what they actually experience in higher education environment, especially in India in relative to that what is existing for the CC users of higher education sector in International arena. It was found from analysis of the data that the experience of Indian users was lower than their expectations while the experience of the international students was always above their expectations for all the variable measured for QoS. This leads to the prediction of QoS logistic Gap model for the higher education users. This finding may help to enhance CC experience for academic user of cloud computing services and can also suggest ways to the provider or institution to improve the QoS by resolving the gaps identified in the Logistic regression Gap model.

Steps taken in measuring the service quality and plotting out the QoS gap logistic regression model are outlined as follows:

1) First step was to conduct extensive literature survey on the topic which:
    a) Disclosed very few articles focused on understanding the QoS of CC and its applications in high education users evaluated in real time perspective.
    b) This exhaustive literature review indicated that there is need of critical understanding of QoS for CC usage in the academic sector specifically pertaining to the students taking science courses, and therefore it also served as the motivation to undertake this project and laid the foundation for the present study.
2) Second step included:
    (a) Selection of Educational Institutes for survey data collection in order to study QoS for the expectation and experience of CC users while using the cloud computing services for their study of science related course materials. Institution that are state-run government college and/or university were selected as majority of students can only afford to attend these institutes for higher education and higher education is thus available to all students from different financial backgrounds.

(b) Next step included selection of variables, for measuring the expected and experienced scores for the QoS. In the present work, we used the established SERVQUAL dimensions which are widely used by researchers for measuring user's perception since the time they have been published in 1985 by Parasuraman et al. Five variables empathy, tangibles, assurance, reliability and responsiveness were selected for the present work.

(c) Reach out to Users which include students and faculty of science background.

(d) Institutes were selected from different parts of India to compare the scores of expectation and experience, and to find if there was any difference in QoS dimensions due to the geographic location. In addition to comparing the values measured for expected and experienced QoS within the institutes in India, it was also compared with the international educational Institution.

(e) QoS Expectation and experience of CC users from State run University of the USA was surveyed for comparison. University of the US was selected as a benchmark for comparison with the Indian university.

3) Next, survey instrument was designed which included questions based on the five selected variables to measure the expectation and experience in two separate sections for clearly getting the scores of what qualities of service users really expected while using the cloud computing services and applications and what they actually experienced or perceived while using these services.

4) As next step, the data collected was organized in excel sheets for analysis. First the descriptive analysis of data was done to find the characteristics of the data like mean, median, mode, variance, standard deviation, skewness and kurtosis. Then ANOVA was conducted for inferential conclusion. Prior to ANOVA, to meet its assumptions, the data was subjected to Levene's test of homogeneity to check the normality of the data. Minor violation was found in the result, but it was fit for ANOVA as it is a robust statistical tool

which can work with minor violations. After Levene's test, the data was subjected to linear regression to measure the relationship among the variables selected for the present study and to test the strength of the relation. For measuring it, Spearman's coefficient of correlation was used. The result after linear regression showed that the variables are strongly related to each other as after plotting the scatter plots for the, the value of r^2 was greater than 0 and less than +1, showing strong relationship. This led to the decision rule and goodness of fit for predicting gap logistic QoS model.

5) Analysis of data using logistic regression model was conducted as to identify the gaps that exist between the expectation and experience of the QoS in users while using CC and services in higher education sector. The QoS variables selected for present study were also correlated with the identified gaps. Suggestions to close the gaps were also listed so that the experience of the cloud computing services can match the expectations of the users' while using them.

Therefore, the current study introduces QoS, as reflected from the users' perspective, and as a measure for the cloud computing performance. The goal of this study was to quantify real time survey data and to evaluate the existing gap between the higher education cloud computing user's expectations and experience, by subjecting it to statistical analysis to obtain overall performance of the QoS. Modification of the SERVQUAL measurement instrument was adopted for academic real time CC users after extensive literature research analysis. The scholar has reported that including the (SERVQUAL) instrument which has been undergone testing over the past several years understanding QoS in varied fields, would function as optimum tool. Relatively, 5 dimensions that included tangibles, reliability, responsiveness, assurance, and empathy, were critically selected to be incorporated in the survey form communicated for academic users to obtain real time QoS data for CC usage and its statistical analysis that would help evaluate the QoS under investigation. Analysis of Variance (ANOVA) used for statistical test for the values of survey obtained as continuous type qualitative data from the Indian

and USA educational institutions. The USA was selected as standard for comparison to the data from Indian colleges and Universities since it has the highest rate of CC service experience and implementation in the field of education globally.

The main inference from this study reflects on the fact that there was a significant difference between academic users' CC expectation of QoS as to its experience. It was also observed upon comparison of QoS of experience between the Indian college CC users which was found to be significantly different from USA University. Currently, limited studies for a reliable standard model of QoS for educators and students that effectively defines the CC usage as "Quality of Experience" (QoE) affected by factors as concluded from their own understanding in fact impacts the recommendation for the cloud service evaluation across various Indian higher educational institutions. The modified QoE Metrics GAP regression Model developed after the quantification of variables in this study can eventually be applied to help gather larger scale data to further benefit towards students success and the decision making process by "Higher Educational" policy makers, and also by the funding management centre which is targeted to serve the 700 Indian higher Educational degree granting institutions and 35,500 affiliated colleges with 20 million students in India, thus benefiting them in not only to achieve world class level education but also to help create excellent job opportunities.

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This research would not have been possible without the trust, encouragement and guidance of many individuals.

Firstly, I would like to express my deep and sincere gratitude to my Internal Guide Prof. (Dr.) Neelu Jyothi Ahuja for her patience, motivation, immense knowledge and continuous support during my Ph.D. work. Her wise advice, useful discussion and guidance helped me throughout the work. She helped me to overcome the various difficulties and challenges that were raised at various stages of the work. My deep gratitude towards her cannot be put in words as I could not have imagined a better advisor and mentor for my Ph.D. study.

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Associate Dean, R & D, UPES and Prof. (Dr.) Maneesh Prateek, Dean, SOCS, UPES for their guidance, encouragement and valuable support for carrying out this research work.

This work would have been impossible without the unending support and understanding by my family.

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My special gratitude to my mother Mrs. Veena Upadhyaya who has always encouraged me in all the difficult times to forge ahead with my goals, my grandmother Mrs. Vimal Sharma for her blessings, special thanks to my brothers Rahul, Anagh and Ekansh for their support and encouragement. Extreme love to my daughter Abhilasha for always understanding my challenges despite her young age, and last but not the least, profound gratitude to my husband Kapil Dev Sharma for his continuous support.

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CC	:	Cloud Computing
DQG	:	Double-Quality-Guaranteed
IaaS	:	Infrastructure as a Service
PasS	:	Platform as a Service
PSO	:	Particle Swarm Optimization
MQMW	:	Multi-workflows
SaaS	:	Software as a Service
SQU	:	Single-Quality-Unguaranteed
SLA	:	Service Level Agreement
QoS	:	Quality of Service
QoE	:	Quality of Experience

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CHAPTER 1: INTRODUCTION

1.1 PREAMBLE

The present study discusses and explores the real time investigation of QoS that is structured in the existing academic system to understand its challenges and gaps that are directly in relation with the QoS perceived (experienced) by the academic cloud computing (CC) users, enrolled in Universities focusing on higher education.

Outline of major deliverables for present study can be summarized in the following points:

- Explore one of the first real time practice of CC in academia population in higher education relative to e-learning
- Measure user satisfaction of cloud computing in academia focused in scientific subject and services, by using the established SERVQUAL QoS dimensions-which include: tangibles, reliability, responsiveness, assurance and empathy
- Analyze QoS as per Logistic regression model to address the difference of QoS expectation as to QoS experience for students in higher education
- Compare QoS perceived value with QoS expected value to identify “Gaps” in QoS
- Compare QoS variables values between Indian and international Universities
- Place the identified QoS “Gaps” in Logistic Regression Model

- Suggest approach to help improve the experience of cloud computing services, based on QoS relationship concluded between user's expectation and experience, for the CC academic users enrolled in higher education

The current work not only contributes towards understanding of existing real time QoS gaps between QoS as expected by user or promised by the provider as compared to QoS perceived (experienced) by the users, but additionally proposes a conceptual logistic regression model to bring into focus the real state of QoS experienced by the users of higher education prevailing in Indian Universities (especially Government funded). It also compares the QoS being experienced by Indian users' and the QoS that is experienced by the International academic users' (USA) from Universities providing online and higher education, to better understand the QoS in CC, in real time.

1.2 PROBLEM STATEMENT

The current real time data survey research on QoS has been traditionally based on the critical pattern of the higher education institutions that are adapting rapidly to the increasing developments in applications of cloud environment, and what is the CC educational QoS for the students, which directly affect their learning, has been an ongoing subject of debate (Elgelany & Alghabban, 2017). After extensive literature survey, it was learned that limited and few studies have their focus directed on real time users' perspective of CC in higher education while maximum research was dedicated on either cloud computing security issues and/or its technical problems. Since the educational institutions are entirely responsible to provide the optimum CC requirements for its academic population. This compelled the scholar to introduce a conceptual logistic regression QoS Metrics Model that could be used to evaluate the five significant dimensions of QoS associated with CC especially relevant to scientific fields learned online or via web services. Therefore, as reported in findings of the study by the scholar, the intent was to define the association and liability between the educational CC contractor and the

enrolled student or faculty at Universities that can be improved and enhanced for use in real time.

1.3 RESEARCH MOTIVATION

It was strongly evident during the literature research and pilot study survey for the topic under consideration, that CC is an undergoing a technological revolution while its implementation for academic users remained lagged behind in several updates. According to the scholar, as she continued her research, there was an obvious realization that in CC, the web provider prefers to charge the online time usage as in contract by its customer while this CC user population too favours the option to pay as these services are needed. Diving deeper into the technological implication, it was realized that cloud computing is increasingly becoming an essential component gradually by every academic centre that is concerned for providing higher education, in addition building popularity of being adopted worldwide in increasing manner. Pooling of the material or data for research through cloud or using the statistical tools available on cloud to analyse data for scholarly research is already being followed. It is majorly due to the high-end services provided through the cloud environment which helps in deploying and managing the information and data in an organized way (Alamri & Qureshi, 2015). Although there are immense learning advantages linked to technology of CC but at the same time challenges and obstacles experienced by these academic CC users cannot be overlooked while using these online services which highly focus on the degree of performance but result in failure by showing difference between the promises made by the providers, as to the expectations of the users' and the actual experience of service by the users'.

Progressing deeper into the literature review, it was revealed to the scholar that a vast number of studies have focused their interest towards understanding QoS related to resource organization, load balancing, traffic management, etc. It became obvious that there is lack of an optimum model to understand the gap prevailing in

CC architecture has not been considered as a major problem. There are many researches pointing on the issues related to providing the services from providers' perspective but there are very few researches pointing on the issues related to quality as per the users' experience Whaiduzzaman, Anuar, Shiraz, Haque & Haque (2014). It was undertaken in the present study to establish academic population as the focus and evolve the CC problems associated with QoS falling under the higher education architecture. Thus, this study was aimed to provide input towards enhancement in QoS, with the implementation of a range of effective suggestions that would bridge gaps in the CC arena of academia leading to an improved adoption of the CC architecture by the higher education sector.

1.4 SCOPE OF PRESENT WORK

This study aims to effectively help embed the current drift of CC technology in Indian Higher Education, by evaluating the limitations and challenges in real time Cloud Computing use by academic end users and its QoS. The study has incorporated users who here with are defined as students and faculty from undergraduate, graduate or postgraduate level from different Educational Institutions across geographic locations. The purpose of Cloud Computing at Indian educational Institutions is to function as a nominal structure to help the implementation and growth of e-learning. Cloud Computing is primarily since it provides fast access to educational services and resources with high performance and support.

Currently, limited real time QoS models for educators and students exist that effectively lay out the map to understand the obstacles that impact CC usage experience by academic users and therefore which leads to impacting the related recommendation for the cloud service evaluation across various Indian higher educational institutions. The new QoE Metrics GAP regression Model developed from the results of this study can eventually be applied to help gather larger scale data to further benefit towards the decision-making process by "Higher

Educational" policy makers, and by the "Funding management" officials. The model analysis from the current study can be essentially useful and serve the existing 700 Indian higher Educational degree granting institutions and 35,500 affiliated colleges with 20 million students in India, thus benefiting them not only to achieve world level education but also to help create excellent job opportunities.

The scope of study was limited to survey analysis of QoS in Expected and Experience in higher education sector and did not include any computational simulations or derivations or capital investments data from service providers.

1.5 BACKGROUND

Cloud computing, also known as technology in which the users can use the services as per their demand, which are provided according to the users' needs. As Almajalid (2017) states in his survey, it is a model for enabling on-demand access to a shared on-line pool of configurable computing resources to its users.

Over the last decade, the emergence of transformative technologies like cloud computing, big data etc., has led to evolution of the Information and Communication Technology sector and its services. These changes, which are more economic in nature, have given way to many transformations in the society and on the cultural front with impact on user behaviour and expectations from the services provided. It has ultimately changed the way users perceive services.

Cloud Computing can be defined as a pool of resources and services that can be delivered through the internet. Institutions together with educational governance bodies are making efforts to innovate learning opportunities with improved infrastructure quality at lower costs as defined in the NMC Horizon report (Johnson, Becker, Estrada & Freeman, 2015)**.** Educational establishments and students are becoming increasingly dependent on information technology for the delivery of higher education study material. According to Almajalid (2017), the interest and demand of students as the end users of online interface is consistently shifting towards cloud computing resources leading it to become the main source

of digital content, interactive classes and other online study material for them. Chen, Gary, Wills, Gilbert, & Bacigalupo (2010) insist that the capability of this class of end users' being able to rapidly evaluate Quality of Experience (QoE) through high quality performance models of a system can be used as a valuable source to improve and facilitate service level agreement (SLA) based cloud scheduling.

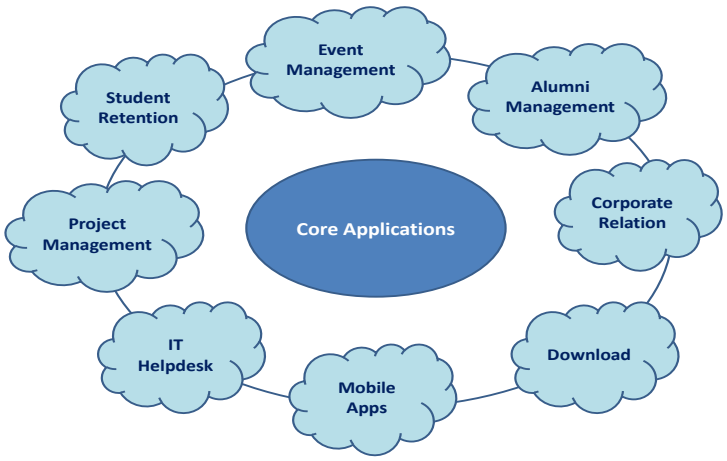

Figure 1.1: Cloud Computing

Currently, internet-based learning applications are being hosted increasingly over cloud environment and increasing the necessity for educational institutions to adhere to CC environment. As observed by Brochado (2009), the involvement of QoS in higher academic fields has been a subject of concern during recent years. This means that all dimensions and features as shown in Figure 1.1, that are characteristic of CC in higher education should be critically reviewed to improve QoS experience by the end user which is the "student/faculty in academia. There seems to be a compromise on the relevance of CC and QoS, but its classification analysis remains an out as a challenge. A report by Maguad (2007) emphasizes the incorporation of CC in e-learning sector in future will entirely be related to identification of QoS gaps and their optimum solution will be needed to achieve success of CC in higher education.

1.6 CLOUD COMPUTING: ATTRIBUTES AND SERVICES

Cloud Computing has come out as a dynamic technology paradigm that has a pronounced fast and effective influence to deliver products and services on-demand to its users from varied fields of life. Per Mell & Grance (2011), CC is configured as a shared pool of computing resources which includes but is not limited to networks, servers, applications, software's over the internet. The Cloud Computing platform provides three kinds of services through internet on pay per use basis; SaaS (Software as a Service), PaaS (Platform as a Service) and IaaS (Infrastructure as a Service) as explained in the following Figure 1.2 presented by Buyya, Yeo, Venugopal, Broberg & Brandic (2009). Davia, Gowen, Ghezzo, Harris, Horne, & Potter (2013) extend this observation of Cloud Computing, implying that an organization or educational department including the end-users' will not be compelled to run or install their own version of the required application alias software. There are numerous studies in progress to understand and improvise upon the Cloud Computing infrastructure such as load balancing, financial constraints, software buffering or security requirements (Srikantaiah, Kansal, Zhao (2009), Jing & She (2011), Zhao, Ding, Xu, Hu, Dong & Fu (2013). Diverse services of Cloud Computing, as in Figure 1.2, incorporates several complicated layers of technical infrastructure but is not covered in detail here since it is outside the scope of the present study. Here, the focus is specifically to understand the extent of QoS to help understand the existing gaps in service that would assist in finding solutions to justify the need and demand of Cloud Computing end users including higher education students and faculties from academic field in Colleges and Universities.

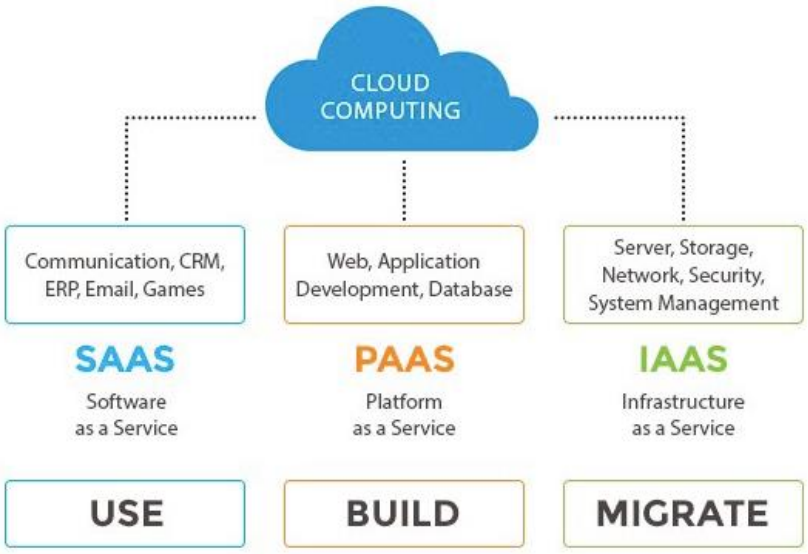

Figure 1.2: The Cloud Computing Categories Defined

1.7 CLOUD COMPUTING AND HIGHER EDUCATION

Cloud computing is a developing trend in the e-learning sector and has drawn the attention of many service providers to the cloud-market in short time, thus providing users with many cloud-based applications for their use. According to Narang, Hudiara & Khurmi (2014), at present, education related services and applications are gaining popularity and there is an increase in their presence over cloud environment further promoting its necessity. Various surveys published in industry publications have predicted that over the next five years, higher education institutions expect to cut 20% of their IT budget by moving their applications to cloud, thus representing a major shift in approach across the industry.

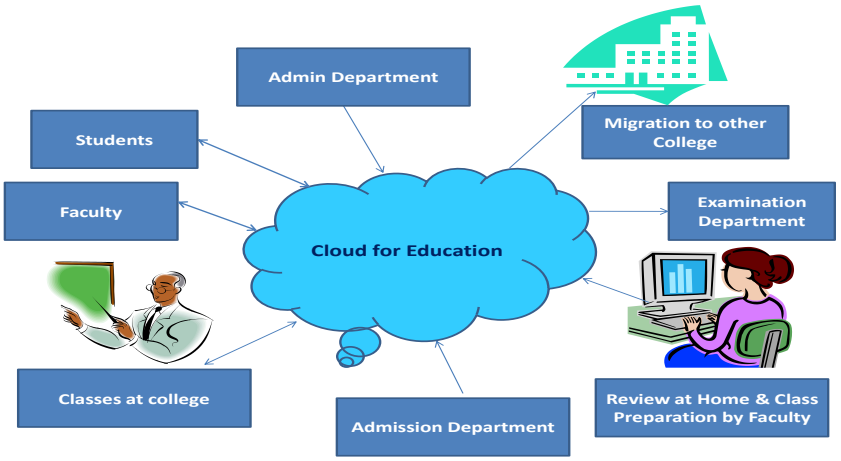

Figure 1.3: Cloud Computing involvement in Education

The dynamic digital technology atmosphere has touched everyone and every place, including the libraries which are extremely important for the population of every academic organization. However, most of these institutions tend to have inclinations to invest less in hardware and expect to move forwards to the use of cloud environment. Such a trend has been on rise since several academic administrations of the higher education institutions have cut the traditional library maintenance budgets starting in mid to late 2000's. This has resulted as management that makes financial decisions for cloud computing requirements, tends to cut costs of computational hardware and related maintenance of computer infrastructure as needed. However, if the progress of future Indian Universities has to be kept in consideration than such financial restrictions or decisions have to be reviewed in order to make the libraries and its contents of higher education which are widely handled by the cloud environment, and finally, the need to make sure that the libraries emerging technologies are in sync, such that they are also accessible across the nation for the higher educational crowd.

A few Cloud based Tools and Applications used in higher Education are shown in the following table:

Table 1.1: Schematic of a few Cloud based Tools and Applications in practice for higher studies by academia

Tools/Application Focus	Examples of Cloud based Tools and Applications
Protein Modelling (Biological courses)	Modeller, PDB visual and validation
Three-Dimensional Image reconstructions	CyroSParc
Document and Article writing	Google Doc, Microsoft 365
Online data space, File Sharing	Dropbox, NextCloud, Google Drive, iCloud, Microsoft OneDrive
Online Learning Environment	Moodle, Blackboard, Edmodo, Schoology, Google Classroom
Calculations	Wolfram Alpha, Khan Academy, IXL
Video Sharing Service	You tube, Vimeo, Dailymotion
Real time Demonstrations	Prezi, Keynote, Google Slides
Project Quantitative Surveys	Survey Monkey, Google Forms
Sharing Presentations	Adobe spark. Slideshare
Micro blogging	Pinterest, Tumblr, Twitter
Picture Sharing	Imagur, Dropbox, Instagram
College /University Management	Fekara, Smatyfy, Vsware.ie

According to Brochado (2009), all online education services should ensure that all service encounters are managed to enhance customer perceived quality. The importance of service quality being provided in higher education has increased over the last few decades; however, the cloud service providers never really provide QoS beyond "you get what you are given." With improvement in QoS being provided, the quantity of applications being deployed by the higher education sector can increase thus increasing the overall adoption rate of cloud computing in this sector.

1.8 CLOUD COMPUTING (CC) AND QoS

In the current technological world of CC, it cannot be ruled out that QoS is related directly to its data service connection and is directly credited to the Data link provider (DLS), therefore giving rise to range of characteristic parameters that apply to type of link and method of computational service by the end user of DSL. Expectation of better QoS includes the technological service awaited by the academic user, which is influenced by the recommendations from peers or past encounters. Experience or Perceived QoS relates to the judgment user confronts after receiving the Internet service.

On the other hand, even though Cloud Computing technological complexity is on rise, the demand of cloud services using cloud platform is exclusively based on underlying requirement that a reliable high-quality broadband must exist to effectively implement cloud-based tools, thus placing variability on "**QoS"** (Zheng, Zhang, & Lyu, 2010). Mostly all the providers of cloud services charge an amount for services utilized and bill the user according to the terms of agreement finalised before using the service. Therefore, to select an optimum service with integrated server is then based on "trust" relationship of previous or current users to the prospective user or enterprise management to follow the recommendation given for QoS of Cloud Computing. It has been previously recommended to practice cloud service selection based on a "trust-enhanced" model for its selection based on experience from previous or current users to achieve effective QoS results in Cloud Computing (Ding et al., 2014, & Pan et al., 2015). However, another solution termed as multi-criteria decision analysis (MCDA) which was brought into consideration for the Cloud Computing user to make the right decision for Cloud Computing selection, included payoff matrix, evaluation matrix and decision matrix. Apart from its complex nature of operation, MCDA claimed to help users for choose the best alternative (Whaiduzzaman, Anuar, Shiraz, Haque & Haque, 2014).

1.9 CLOUD COMPUTING: QoS AND PERFORMANCE IN HIGHER EDUCATION

Examining the variables affecting the performances of QoS is very difficult for commercial or academic CC providers and data centres since they face challenges in understanding the real time QoS associated with academia user, including concerns like minimum cost with maximum in-flow of services (Hadji & Zeghlache, 2012). To improve the service quality, it would be prudent to monitor and evaluate the gap between the promised and experienced quality. Availability of this measurement unveils QoS in CC with the missing elements that can help identify **service gaps**. Figure 1.4 shows different concepts embedded in QoS performance, which is therefore defined as assigning resources to the application which in turn guarantees a service level along the magnitude that includes performance, availability and reliability.

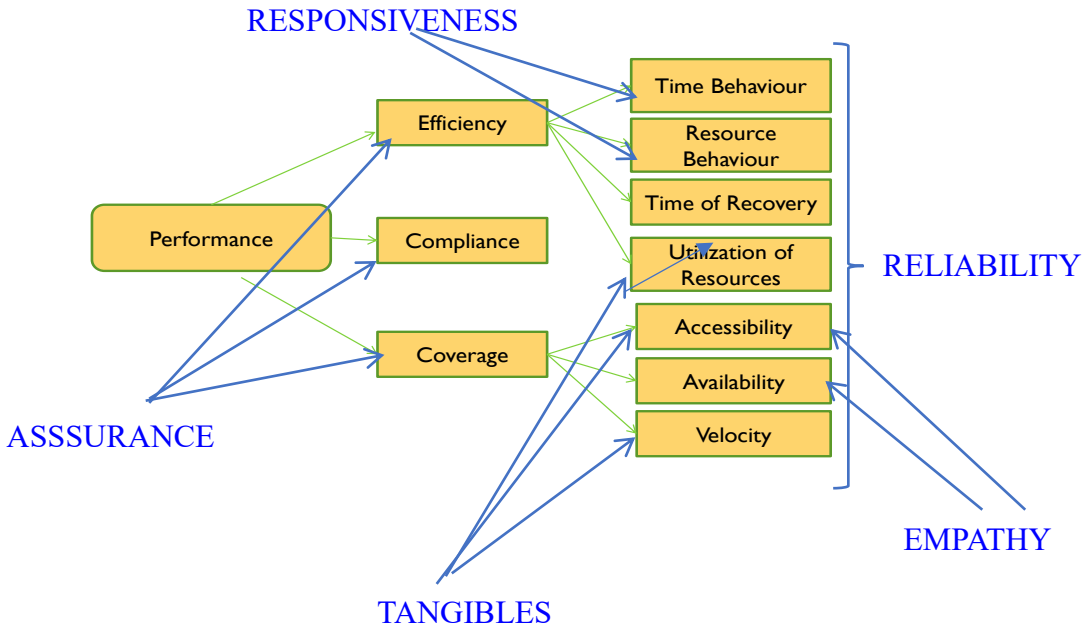

Figure 1.4: Characteristics of Performance metrics

One of the important relations of performance can be effectively linked to better experience of QoS. The stage of optimum performance as from the end user view would mean that the layer soft infrastructure has been set up technically to meet the customers' criteria which include not only financial aspect but also speed/velocity, security etc. as shown in the above Figure 1.4, depicting the features of performance metrics. In this context, companies like Google and Amazon have gained a reputation for their Cloud Computing services based on the service quality they provide to their end users.

1.10 OBJECTIVES OF RESEARCH

The objective of present research topic which relates to mapping the QoS Gap Model for evaluating use of CC applications and services together with its emphasis on e-Learning in Higher Education Sector, is to, address the following *Problem Question:*

"How can we identify the specific QoS metric affecting the CC academic user?"

The steps followed data criteria collection set up are as:

- Identify variables for QoS in CC from extensive literature analysis for optimum QoS in higher education undertaking population, and verifying by executing a pilot data collection.
- Conduct quantification of selected variables selected for QoS by implying Descriptive Statistical approach and one-way ANOVA for Inferential conclusion, for analysis for the data collected in real case studies.
- Proof "Goodness of fit" for the Derived QoS metrics model to relate the service quality that is expected as to what is perceived by the scientific academia group.
- Understand existing gaps in QoS by analysis of results relative to proposed model, to help find difference between QoS experience to QoS expected values from current survey data collected in real time cases from higher education users.

1.11 RESEARCH QUESTIONS AND HYPOTHESIS

The study was focused on investigating the QoS related to Cloud Computing facilities accessible at higher education in Indian colleges and Universities. Additionally, this study examined if the QoS was affected based on geographic locations and therefore collected data from international Universities.

(a) Formulation of study exploration inquires which were outlined in the current real time data collection survey, are as follows:

- What is the Current Status or Experience of QoS by end users at the Educational Centre for CC
- How to approach for targeting end users Expectation of QoS by end users at the Educational Centre's for CC
- How to select instrument for Variable Identification (decided on using SERVQUAL model-grouping in dimensions as: - Empathy, Assurance, responsiveness, Tangibles, reliability and overall service quality)
- QoS regression Model development –pointing to its differences and similarities as found within Educational population as well as between National and International / USA Educational Sectors)

(b) Hypothesis outlined

Based on the above stated research questions, the following hypothesis were framed by the scholar using the selected metrics variables for the current study, to conceptualise the predictive Gap Logistic Regression Model, for analysing QoS from users' perspective.

- **Hypothesis I (H1)-*Empathy***
- **Hypothesis II (H2)-*Responsiveness***
- **Hypothesis III (H3)-*Assurance***
- **Hypothesis IV (H4)-*Reliability***
- **Hypothesis V (H5) -*Tangibility***
- **Hypothesis VI (H6) – *Relativity***

1.12 RESEARCH METHODOLOGY

The steps that were followed are mentioned as below:

- Identify variables for understanding QoS in academic CC by utilizing extensive literature analysis related to studies for achieving optimum QoS in higher education population, and verifying this approach by executing a pilot data collection.
- Conduct quantification of selected variables by implying Descriptive Statistical approach and one-way ANOVA for Inferential conclusion, for analysis for the data collected in real case studies.
- Proof "Goodness of fit" for the Derived QoS metrics model to relate the service quality that is expected as to what is perceived by the scientific academia group.
- The conceptual model in the current study is mapped and then validated by hypothesis testing.
- A Gap Logistic Regression Model predicted for analysis of cloud computing services' quality as perceived by users as compared to QoS expected by the university level academic customers of CC.

Understand existing gaps in QoS by analysis of results relative to the proposed model, to help find differences between QoS experience to QoS expected values from current survey data collected in real time cases from higher education users.

1.13 SIGNIFICANCE OF THE CURRENT WORK

The current study reports the finding of a real time survey from cross-sectional data which concluded that there is limited emphasis on QoS limitations and challenges as per academic users' perspective. The current study focused on the colleges and universities of higher education and the users were mainly from the science stream. The scholar's current research has investigated the real time QoS and evaluated that there exists a gap in CC services in academics as to what is supposed to be delivered and expected by users. The SERVQUAL constructs validated in the prior research

have been used here which can be also used for evaluating the QoS gap existing in real time use of the CC service's quality performance against academic users' service quality needs. As such, the contributions can be summarized as following:

1. Extensive literature research performed for the current study to understand the difference between Quality of Service (QoS) expected and Quality of Service perceived by the users of the higher education sector. The study highlights and analyses the real time Cloud Computing data, which is collected by surveying the students and faculty of different universities (national and international for comparison).

2. The Proposed Quality of Service Model aimed to improve users' (students, librarian, staff and faculty) experience with Cloud Computing (CC) in the higher education sector, especially in Indian government-based sector.

3. Conducted extensive data collection to identify and select the variables that would help measure the user satisfaction for cloud computing applications in the higher education sector.

4. Quantified selected variable identified using descriptive statistics and inferential conclusion.

5. Quality of Service Logistic relation model proposed and implemented to address the Quality of Service expectation of users in the higher education sector for achieving improved Cloud computing experience.

6. Presented detailed analysis of results and findings that showed the existence of a huge gap in all five dimensions measured and compared, thus leading to conception and construction of a Gap Logistic Regression Model for QoS under this CC sector. This was a direct outcome of the impact of Quality of Service of Cloud Computing survey analysis for QoS offered for CC at higher educational Centres in India when compared within National and with International Educational Centres.

7. Proposed approach to improve Quality of Service (QoS) in Indian educational sector based on real time case studies with lower mean difference in QoS in relation to “Expected Score (ES)” – “Perceived Score (PS)” values, thereby addressing specific Cloud Computing (CC) dimensions using follow up survey as a tool, in another long-term research which was not in the scope of current study.

1.14 DEFINITION OF TERMS

Cloud Computing (CC):

Cloud Computing is an emerging technological paradigm which provides efficient computing by centralizing storage, memory and computing capacity. It provides software to the users without any requirement to invest in buying them and the user can compute using these without having knowledge and expertise about the software. Cloud computing works with a layer of abstraction and provides on line access to applications and services centralized by the providers (Alshuwaier et al., 2012).

Demographic Factors:

The demographic data taken from the users including age, gender, qualification, income and occupation of the user to evaluate which factor influences the QoS expected or experienced by the academic population.

Service Models:

Software as a Service (SaaS): Software and applications offered by the provider that comprise of not only the applications provided to the user in the form of services over the internet but also to the shared hardware and software through which these are made available to the user (Armbrust, Fox, Griffith, Joseph, Katz, Konwinski, Lee, Patterson, & Rabkin, 2010). The user has no control over the cloud

infrastructure that comprises network, servers, storage capacity, resource pooling and load distribution etc. (Mell & Grance, 2011).

> **Infrastructure as a Service (IaaS):** The capability offered to the user for the utilisation of storage resources and other fundamental computing facilities including high end statistical software and applications. During provisioning of these services to the user, there is a layer of abstraction which hides the working and layout of the infrastructure e.g. network used to provide cloud computing applications, shared resources at the data centre, storage servers for storing the data of the user, load scheduling etc. (Mell & Grance, 2011).
>
> **Platform as a Service (PaaS):** PaaS acts as an abstraction layer between the SaaS and IaaS. It is used as a platform by the deployers and developers of cloud computing applications to write and develop the applications that run on cloud. It provides a platform or an environment to the developers who can work according to the particular platform's specifications (Rani & Ranjan, 2014).

Higher Education Cloud Computing User / End User: Includes faculties, the IT administrators of the libraries, college undergraduate, graduate and postgraduate students. In academic institutions, Librarians have been considered to play an important role to enrich libraries (physical or web resources) with updated publications for University students and faculties together with providing information about digital learning. Cloud Computing has led effectively to several new innovations to realign the educational field bypassing any barrier of distance or expensive device dependability, aiming to universal achievement of higher education (Alamri & Qureshi, 2015). In addition, composition set up of resources for CC at the facility, greatly influences QoS which has become a major consideration when addressing its underlying challenges of trust and availability at the user's end. However, QoS is known to also be affected by the involvement of

resources occurring as accounted by private, public or hybrid cloud computing (Ardagna, Casale & Ciavotta, 2014).

Provider: The service provider means the company or organization responsible for providing the cloud computing services including the network, servers, storage, and many other services required to run the applications on users end (Mohan, Pandey, Bisht & Pant, 2017).

QoS: This is the measure of overall functionality of the provided internet service to the available platform. To measure QoS or its performance qualitatively, factors that are considered include reliability, accessibility, velocity or speed of transmission. According to Iosup, Ostermann, Yigitbasi, Prodan, Fahringer & Epema (2010), these factors are measured as a rating to create a statistical evaluation that will help understand the difference between promise of the desired service made by the provider, expectations of the user and the actual experience of the user, like in scientific computation. Studies have supported that identification of all these metrics can help improve QoS in CC specifically for students in higher education, when the strategy of sophisticated framework is implemented to multiple consumers and multiple providers (Wang, Wang, Che, Li, Huang & Gao, 2015).

QoS Expectation:

It is the expectation of the user about the service quality that they will receive while using the service. It is formed by taking into consideration the promises made by the provider, by the views of the other users, advertisements (Pena, Silva, Tronchin & Melleiro, 2013).

Quality of Experience or Perception (P_i) (QoE):

Traditional tools (like router quality, firewall etc.) do not actually intend to measure the end user's perception to the problem occurring in meeting their need by providers. Thus, *measure of* ***Quality of Experience*** **or Perception (P_i)** ***(QoE),*** is derived from the data evaluated after extensive survey and quantitative analysis

(Chang, 2014). QoE is related to assessment of the technological service satisfaction provided to the customer. However, several factors influence QoE and having a structure that would emphasize on all will lead to a better but complicated model that can be involved in management and for speculative judgement regarding specific CC service selection. Thus, it has been stated that the QoE should have a framework to ensure its stakeholders, users and students that are all involved in this developmental process have a defined model to follow (Jarschel, Schlosser, Scheuring & Hobfeld, 2011).

SERVQUAL:

According to Parasuraman, Zeithaml & Berry (1988), SERVQUAL is a service quality measurement instrument for measuring the service quality being provided to the user and finding the gap between QoS expected and QoS experienced by them. It has been extensively used by the researchers in the last many years to measure the qualitative data by taking input from the user and analysing it.

1.15 THESIS ORGANIZATION

Chapter 1 is the introductory chapter that describes the proposed study, problem that was investigated, the scope of the study, research questions answered in the current study, hypothesis framed, research methodology, definition of terms used in the current work, significance of the current work and thesis organization.

Chapter 2 covers the survey of literature including the analysis of existing QoS models in cloud computing and establishes the need for the present work. A background and history of cloud computing and QoS, SERVQUAL instrument, statistical tools used for descriptive analysis and inference conclusion and the background of gap model is also discussed.

Chapter 3 presents in detail the research methodology including the research design, population and samples selection, designing the survey instrument, data

collection and organization, the methods used in the study for analysis of the data and prediction of logistic model.

Chapter 4 presents in detail the implementation of research methodology including the research design, population and samples to progress towards data collection and model mapping.

Chapter 5 presents the results obtained after the quantification of the selected variables using Descriptive Statistical approach and one-way ANOVA for Inferential conclusion, it also covers proof of "Goodness of fit" for the predicted QoS logistic regression metrics model to relate the service quality that is expected as to what is perceived by the scientific academia group.

Chapter 6 contains a summary of the deliverables, recommendations for further study, limitations and conclusion of the current study.

1.16 SUMMARY

The above introductory chapter describes the proposed study, problem that was investigated, the scope of the study, research questions answered in the current study, hypothesis framed, research methodology, definition of terms used in the current work, significance of the current work and thesis organization.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

CC is inevitably embedded in the Higher Education system and stands out as an additional marker in todays' rapidly developing competitive technological World. This is now a major factor affecting the decision making for students and academicians when it comes over the selection amongst several existing educational organizations. This selection process is critically based on the rating of success achieved which is distributed between students' education quality with respect to their career placement. However, Peter & Waterman (2006) stated in advance that "excellence in education" relates directly to success. The educational organizations now face several challenges to deliver superior quality education which in fact is directly affected by service quality offered and perceived by the students at their centres. To keep up this competitive trend among the educational organizations which in return benefits both the students and academics staff, measure and understanding of "QoS" is identified to play a major role in shaping the day-to-day strategic policies in the higher educational sector.

Cloud computing applications have a wide variety of end users, though these all may have different requirements in terms of meeting an optimal QoS. Therefore, providing a guaranteed QoS environment in such a vigorous environment is a challenging task. To understand the diverse layer of Cloud Computing and QoS interaction, researchers have investigated various metrics to propose manageable mechanisms, systems and structure which can analyse into different features of QoS requirements in relation to end users of CC in business, education etc.

2.2 BACKGROUND OF CLOUD COMPUTING (CC)

Although, the first scholarly use of the term 'cloud computing' was by Ramnath Chellapa in 1997 during a conference but as significant bandwidth was offered by internet late in 90's, its development was delayed. Cloud computing technology had its boom in early 2000s when organizations started developing business models and corporate solutions using it. In 2002, Amazon Web Services provided cloud computing services including storage and computation. 'Cloud computing' term started appearing in literature around 2006, being referred to as a new electronic marketplace and its adoption by the business industry (Wang, Archer &Zheng, 2006). Armbrust et al., 2010, came up with the idea that the cloud computing applications services can be divided as IaaS (Infrastructure as a Service), PaaS (Platform as a Service and SaaS (Software as a Service). According to Mell & Grance, 2011, the cloud is classified in four deployment models, public cloud when the services are made available to the public in pay per use manner, private cloud refers to the internal data centres of the organizations, community cloud when the cloud infrastructure is used by a specific community from organizations that have shared concerns and Hybrid cloud when the cloud infrastructure compose of two or more distinct cloud models (private, public or community) . The higher education institutes can deploy the public cloud model for their students and faculty as the investment is less and they don't need large IT infrastructures for their needs.

2.3 CLOUD COMPUTING (CC) IN HIGHER EDUCATION

According to research reports "Indian Distance Learning Market Analysis" in 2013, it was estimated that the online education market in India will increase by 24% from 2011-12 to 2015-16. However, the aim of the government to raise its current GER from around 13% to 30% by 2020 that will also boost the growth of the distance education in India (Jalgaonkar & Kanojia, 2013) which has been true in this respect that many universities are moving towards the adoption of cloud computing as it helps in reducing the difference between on-campus and off-campus activities and provides solutions to many challenges encountered by the educational institutes.

According to Alamri & Qureshi (2015), universities should implement online education to students and share education material like lecture videos, online classrooms and books. Cloud computing also supports the educational institutes by providing an effective deployment model to resolve their common challenges such as cost reduction, quick and effective communication, security, privacy, flexibility and accessibility in turn also benefiting their students. (Alshuwaier, Alshuwaier & Areshey, 2012). This basically lays the foundation of the benefits to students after the adaptation of cloud computing in universities and colleges. But it also raised questions whether the service quality being provided to the students and faculties of higher education sector is as promised to them or not. And the need was felt that the QoS in the educational sector should be monitored by narrowing it down to the user's experience for the improvement of the cloud services being offered to them (Alsufyani, Safdari & Chang, 2015).

2.4 CLOUD COMPUTING AND QoS MEASUREMENT

Researchers have been focussing widely on the measurement of various dimensions of quality of cloud services being deployed at higher education institutes and universities (Krsmanovic, Horvat & Ruso, 2014). Schwantz (1996), focused on the age factor, to obtain service quality during the higher education period. The age factor categorized the students into two groups one as "traditional" students' (age below 25 years) and another as "non-traditional" students (age 25 years and older). It was performed to explore the QoS between the two groups of students, traditional students as to people who were working or adults and was registered in higher education students. The study could not find any difference and it was concluded that age or job criteria did not have any influence on students' perception of service quality. In 2008, Sawhney et al presented the findings of the study based on the analysis of data using qualitative and quantitative tools helping in identification of service quality tools, where faculty is termed as the internal "Customer" was done to evaluate the value of services rendered in the academic organization. It was suggested that adoption of the "satisfaction factor" tool would lead to a more

integrated and managed faculty profile, which would contribute to improving service quality in higher education. But it only considered faculty as the user not taking students in consideration.

In a study of users of cloud computing by Katz, Goldstein & Yanosky (2009), showed that more than 70% (72.1) users are concerned about the security in digital transactions, and more than one-half (58.7%) of them expressed their concerns about the consents for regulations limiting their adoption of these rising offers of services. This concern of the users about the value of service quality being provided to them led many researchers to work on defining and measuring the quality of different technical aspects of cloud computing services. In 2009, Xu et al presented a scheduling strategy of multi-workflows (MQMW) to address the issue of multiple workflows with different QoS requirements. Though in this case, QoS constraints like reliability and availability were not considered. Some leading companies took the initiative of developing QoS solutions for the higher education users.

IBM Virtual Computing took the initiative of developing Virtual Computing Lab to address a growing set of computational needs and user requirements for the educational sector that is directed to Universities. This system could deliver solutions required by the users for variety of service environments anytime and anyplace on demand/reservation (Moothor & Bhatt, 2010). A system which tries to maximize use of local resources while minimizing the use of external resources without compromising the QoS requirements was developed by Den et al in 2010 but it did not deal with the failures which may occur after the scheduling has been finished thus which may result in increase in cost of execution and effect overall quality. Xiao, Lin, Jiang, Chu & Shen (2010), proposed a scheme for QoS provisioning to minimize the cost of computing resources while satisfying the required QoS metrics. They considered the statistical probability of the response time as a practical metric rather than typical mean response time; however, the provisioning algorithm was not used to integrate security and privacy metrics.

Expanding the research on the subject, Buyya, Garg & Calheiros (2011) recommended a framework for managing QOS necessities putting relevancy on the Service Level Agreement. It consolidates the technologies available virtually with the provisioning of the resources in the market for providing versatile allocation of resources to the applications needed by the users. Though it highlights the understanding of various technological aspects with marketing, the model put by him does not support different providers for IaaS, PaaS and SaaS of cloud together. Ardagna et al., (2011), state that QoS is an important part of benchmarking in cloud computing Its management is important for any organization and it pertains to reliability, availability etc. The international standard ISO 25010 (ISO/IEC 2011) defines the quality of system as the extent to which the system fully fills the promised features and gives continuous terms for defining, computing and assessing quality of the software product. It also provides a set of determinants for quality against which pre-defined quality requirements can be compared for completeness. In 2011, Zhang & Yan, presented a framework for QoS management process which is adaptable for mobile computing using cloud to manage assured QoS assurance. Yet a model with such suitable configuration could not be generated. A workflow scheduling algorithm based PSO (Particle Swarm Optimization) was proposed by Badger, Bernstein, Bohn, de Vaulx, Hogan, Iorga, Mao, Messina, Mills, Simmon, Sokol, Tong, Whiteside & Leaf (2014), in comparison to the traditional optimization technique that considers only the workflow execution time, the mechanism proposed can optimize up to seven parameters. Many scholars have been stating for long that online learning would overtake the higher education sector and thus become mainstream knowledge source demanding guaranteed service quality. Feng, Garg, Buyya & Li (2012), presented a resource allocation optimum model for maximizing the revenue. However, it took only the mean time taken for generating response into consideration as a QoS attribute. Thus, from the customer's point of view the model has very limited use. They presented an architecture in which the agent technology was used for handling the tracking of QoS requirements requested and used the

licensing agreements for supporting the validation and verification of the service quality. It also had a weakness that was lacuna of self-learning algorithms for determining the timing resource allocation automatically (Feng et al., 2012).

Karim, Ding & Miri (2013) presented a procedure for mapping requirements of the users for QoS while using the services provided through the cloud and aligning them to the correct specifications of SaaS and then also align to the best available IaaS service that can guarantee an optimal QoS. The calculation of QoS was done for end to end mapping. Defined set of rules was used for the process of mapping. They used a case study to demonstrate the solution and validate it; however, they did not conduct an evaluation of the performance which was based on real-time data set of QoS measurement. Manuel (2015), proposed a trust model which resulted in the identification of important QoS variables like availability, reliability etc. Carr (2014) was of the view that Cloud model is pivotal for higher education sector and developing a cloud adoption strategy is top priority for them. Main pillar of online education lies in providing & developing high quality reputation is a pillar of cloud strategy in the higher education sector. The issue regarding the observation of time of response for determining the quality of the cloud services by using a system of systems approach was explored and EMMRACC (Enterprise Monitoring and Management and Response Architecture for Cloud Computing) approach was employed. It worked on providing structure where points can be identified to monitor and QoS metrics. Though an excellent approach was used, no real time implementation was carried out in real or federated clouds (Hershey & Silio, 2014).

Shawish & Salama (2014), proposed a framework of cloud computing which was focussed on service quality where various cloud providers who were working independently can co-operate to acquire more resources in peak time to attain their targets regarding QoS related to pre-defined licensing agreements between the customer and the provider. The well-defined characteristic of this framework was addressing the quality related capabilities for addressing management of resources dynamically for the improvement in the effectiveness of the usage resources.

However, there was no construction of complex services by using services from different providers of cloud services and there was no provision made for distributed denial of service attacks. A model was proposed by Xiao et al., in 2014 to assist in the designing and the construction of the ECC through SaaS, PaaS and IaaS and for the same time monitoring and dynamic analysis of the QoS factors. Based on this model, analysis and testing models were also generated. There were some limitations of this work for example no adaptation of the attributes and solutions of Internet of Things in the proposed framework and as the experiment on the field.

2.5 MEASURING QoS IN HIGHER EDUCATION SECTOR

The dynamic nature of the CC is well documented thus it becomes an utmost concern for constant observation of the QoS features that are essential to enforce the legal Service Level Agreement between the provider and the customer. Apart from it, various other features for example reliability, security and performance should also be considered especially for users who may want to outsource their valuable data (Akpan & Sudha, 2015). It was also found that there is also a lacuna of research which focuses on the efficacy of personalized learning in higher education. Government leaders in India cite that ensuring quality control is the main obstacle (Johnson et al., 2015). The existing cloud computing systems being provided to the higher education institutes, mostly fail to solve the issues of reliability, privacy, security and integrity. The applications and services are costly, also the students are not able to access them off-campus as per their convenience (Elgelany & Alghabban, 2017). This developed a need to come forward with an innovative approach to understand QoS in CC services being provided in the higher education institutes. In 2017, Jadhav et al proposed a Double-Quality-Guaranteed (DQG) leasing plan which was able to attain more profit than the Single-Quality-Unguaranteed (SQU) leasing plan to ensure the QoS in cloud computing.

Odun-Ayo & Agono (2018), proposed a four-layer model for QoS and energy efficiency in mobile CC. They also addressed the concern that QoS can be different when analysed from provider's and user's perspective and that there should be implementation of cloud computing such that users should have a perception of quality and their satisfaction should be guaranteed. Also, Ezenwoke, Daramola & Adigun (2018), after their evaluation of qualitative and quantitative quality attributes, proved that the applicability of heterogeneous similarity metrics for QoS ranking of cloud computing service in relation to users' heterogeneous requirements. Laghari (2013), proposed a QoS framework for real time network monitoring and client device monitoring for live video streaming and it also allows policies for changes during run-time environment. Eisa, Esedimy & Rashad (2013) also proposed a model "with seven quality attributes for real system understanding by cloud computing users'. The model combines the best values for each criterion and covers economic, technical, organizational and political areas of cloud computing.

2.5.1 SERVQUAL Instrument for measuring QoS

Over the last few years, the software industry has focused on improving the processes to develop products that satisfy the user's quality requirements. This has been known as "user experience" which refers to ease of use, reliability, stability etc. (Trudel, Lavoie, Claude & Suryn, 2006). According to Smith, Smith & Clarke (2007), universities implement SERVQUAL models to assess satisfaction not only with teaching and learning, but with support services such as information technology. It plays a major role in the adoption of cloud services by the higher education institutes. Due to its still evolving nature, there are numerous shortcomings that impact cloud computing services like slow applications, need to manage and ensure service quality, need to monitor the performance of cloud applications, and ways to increase and improve such services overall. NIST, Special Report in 2015 defined the QoS metrics for the measurement of quality and variables were identified which can be related to QoS in clouds. Elgelany &

Alghabban (2017) focused on understanding the position of cloud computing adoption in higher education institutes by measuring the service quality being provided to the users'.

In general, it is difficult to measure and quantify service quality. The main purpose of measuring service quality is to ensure whether service is provided as per the expectations of the customers. The main purpose in the measurement of QoS is to find if there is any gap between the QoS expected by the user and the QoS experienced by them (Parasuraman, Zeithaml & Berry, 1985). There are various tools which are well known for service quality measurement or satisfaction of the user. The most prominent instrument in attempting to systematize the service quality is "The gap model" of service or SERVQUAL developed by Parasuraman et al. (1985). This conceptual framework was developed initially to measure customer perception of service quality for the financial service sectors but later extended to sectors such as hospitality, telecommunications and healthcare. In 1988, Parasuraman et al., modified their model and identified the variables responsible for measuring the QoS. The five identified variables were tangibles which measures the quality of physical facilities, equipment's, and appearance of the services being provided to the user, reliability includes the ability of the provider to provide the service offered dependably and accurately according to the user, responsiveness means the willingness of the provider to help the customer in solving his issues regarding the services promptly and accurately, assurance means that the provider and his team is able to install trust and confidence in the user regarding the services being provided and able to gain the confidence of the user and empathy that includes the caring and individualized attention given by the provider to all the users in solving their problems and providing the promised services (Parasuraman et al., 1988). The SERVQUAL's model thus developed by used a survey to ask respondents for an indication of their expectations as well as their perceptions of service, and establishes the gap between the two. It has been used since last many years by the researchers and professionals to measure service

quality. SERVQUAL has also been extensively used to measure QoS in higher education institutes (Abili, Thani, Mokhtarian & Rashidi, 2011).

2.6 REGRESSION MODEL REVIEW

Regression models have been proposed earlier by the researchers for measuring the QoS for example, Academic cloud ERP model by Surendro and Olivia in 2016 (Surendro & Olivia, 2016). In this model the researchers have proposed a framework for assessing the quality characteristics along with the cloud computing attributes of the services being provided for working on ERP modules required by the academic institutions for organizing and optimizing their working process through cloud computing. They based their model on the quality measurement framework proposed by Wagner in 2013 for software product quality control. Another empirical study was done by Hamidi & Rouhani (2018) to find the effects of cloud computing in e-learning. In this study, they measured the service quality comparing the traditional learning system and the new e-learning introduced through cloud computing in E.M. University of Tehran, Iran. They measured quality by using management tools and Benchmark Apache Test. They selected QoS indicators like throughput, response time, scalability and accessibility for measuring the quality of the technical workflow of both the traditional and the new cloud-based system. Iji, Abah & Anyor (2018), carried on a study to understand the effect of cloud-based service on the learning environment of students for the subject mathematics in Benue State University, Nigeria. They adopted an ex-post facto research design for this study and after analysing the data they concluded that cloud services had a high level of impact on the learning of mathematics on the students of the university. Another study to measure the effect of using google docs for after class assignment activities was carried on by Wang (2017) on the students of business writing class of a university in Taiwan. He evaluated the qualitative and quantitative responses of the students and derived the conclusion that google docs app was effective for the students in completing their work.

2.7 DESCRIPTIVE STATISTICAL ANALYSIS AND INFERENTIAL CONCLUSION FOR QUANTIFICATION OF VARIABLES

The first step towards the prediction of regression logistic gap model for measuring QoS, the quantification of data should be carried out, to prove that the data and the variables selected are fit for the model. It can be obtained by subjecting the data through descriptive analysis and inferential conclusion using ANOVA. Descriptive Analysis is data simplification. The aim of descriptive analysis is to quantitatively analyse the data by finding the trends and variance of the data. It is used to describe the main features of the qualitative data by quantifying in terms of central tendency indicators i.e. mean, median and mode, spread of data is quantified in terms of standard deviation and variance. According to Marusteri & Bacarea (2010), Inferential conclusion is used to describe the data to draw conclusive results for testing null hypothesis (there is no difference among the groups) and alternate hypothesis (there is some difference among the groups). The data collected and analysed is termed as continuous data which is the data collected from the users by any survey instrument. It is called continuous as it changes from user to user for it depends on their personal perception of the service offered. Cherry (2019) outlines some great approaches to cross-sectional study for the analyses of the data used from a population at a specific point in time. The current work is also a cross sectional study with continuous data as the data collected is at a certain point of time and of users having similar characteristics. For Inferential conclusion using ANOVA, as a preliminary check, first the normality of data is tested by using the Levene's test. It is a very popular tool for checking the variance of data, its approach is robust and powerful in finding the homogeneity of data variance. It is used to prove the pre-assumptions of ANOVA (Gastwirth, Gel & Miao, 2009).

To predict a logistic regression model the data should be quantified. To describe the relationship among variables, the data is subjected to linear regression. Two variables are taken at a time for determining the association between them, one is called the dependent variable (to be explained) and the other is called the predictor variable (response variable). It provides statistical dependence between them. If

both the variables are continuous then a correlation coefficient is calculated to measure the strength of relationship between them. A linear regression line is formed by plotting scatter plots. Slope of the regression line is known as the regression coefficient for example Spearman's correlation coefficient (r). It describes a monotonic relationship, thus providing information about the strength and direction between the two continuous variables. To get the fraction of the overall variance, r^2 is used also called the coefficient of determination. (Schneider, Hommel & Blettner (2010). In the current work, continuous data collected is subjected to first Levene's test to find the variance and then to regression analysis for meeting the assumptions of ANOVA thus leading to inferential conclusion. ANOVA is a statistical tool based on linear regression and models that quantify the relationship between two variables. One of the ANOVA assumptions states that the data should be normally distributed, which is commonly tested using the Shapiro-Wilk test if the sample size is less than 50. But ANOVA can also work with the violations of homogeneity of variation if the sample size is large. One of the non-parametric tests like linear regression or Levene's test can be used for quantifying the data before subjecting to one-way ANOVA. It evaluates the significance based on F-square value. One-way ANOVA is calculated by using three metrics, grand mean, sum of squares and mean square. Larger F-score means lower p-value which rejects that the null hypothesis and lower F-score means larger p-value which proves that the null hypothesis is true (Schneider, Hommel & Blettner, 2010). The inference conclusion obtained after ANOVA leads to the proving of goodness of fit for proposing the logistic gap model.

In the current research study, the SERVQUAL instrument has been tailored to evaluate the QoS in CC in real time within the academia population in both Indian and USA universities. In short, the best approach based on literature review emerges out that there is a need to optimize Cloud Computing by understanding and improving QoS parameters that affect quality and performance of its service to end users in higher educational sector.

2.8 SUMMARY

The literature review chapter summarizes the theoretical concept of CC and QoS in higher education. It was also incorporating extensive review of literature about the concept of how minimum focus is on understanding QoS as per academic users' perspective as the majority of the studies focused either on technical concepts or security issues of cloud computing like the cloud workflow. Further, this chapter includes the CC integration concept from many other researchers who have proposed that attention should also be added on the dynamic resource pooling, network traffic controls etc. in order for handling QoS in cloud computing or issues of higher education. The decision of selection of SERVQUAL as measurement instrument for this study to predict the logistic gap model in order to measure the QoS in higher education has been established. The significance and requirement of the current work in the measurement of the gap that exist between the QoS expected by the academic user and QoS actually experienced by this user has also been brought into focus in this chapter.

CHAPTER 3: METHODOLOGY STRATEGY DESIGN

3.1 INTRODUCTION

The current quantitative cross-sectional study was focused on and designed for investigating the QoS related to Cloud Computing facilities accessible at the higher education institutes in Indian colleges and Universities. Additionally, this study examined if the QoS was affected based on geographic locations and therefore data was collected from an international university for comparative analysis to find if there exists any difference between the QoS being perceived by the users at Indian and International university and college level. The results obtained were used in predicting QoS Logistic regression model to address the expectation of students in higher education for improved Cloud computing experience. This chapter also focuses on the research methodology applied including selection of variables for the study, selection of the institutes for data collection, designing of the survey instrument, data collection methods, statistical tools applied for quantification of variables and prediction of logistic model for QoS in CC applications and service in University academics.

3.2 RESEARCH DESIGN

The current study includes a quantitative research strategy as it involves the use of quantitative methods in collection and evaluation of the real time QoS data received from survey of the academic users of CC services in Universities population, especially obtained from the faculty and students of state managed and run higher education universities and colleges in India. Quantitative research design consists

of a statistical approach to quantify and objectively measure the reality data. It involves collecting the data numerically and using statistical tools and mathematical models for data analysis and using the results obtained to accept or reject the null hypothesis (Sawyer, 2009).

The initial steps involved in the current study were to select and identify the variables based on which the survey instrument could be interrogated QoS in real time for the higher education population. The current study is classified as a cross-sectional study and progressed by using a variable measurement instrument to collect data through online surveys. The survey instrument must address the research questions. The data collected involves a set of questions to bring out the information in numeric form gathered on text or measuring scales (Klug & Bai, 2015).

3.3 RESEARCH QUESTION FOR REAL TIME QoS IN CC

Two primary research questions on which the current work is based are:

(1) What is the difference, if it exists, between the real time measurement of QoS as expected by the academic users' when compared to the QoS experienced by them, while using the cloud computing applications and services? (Focusing on the state managed and run colleges and universities in India), and,
(2) Is there any difference between the real time dimensions of QoS expected and QoS experienced by the Indian and the international University users of the higher education sector, in state run colleges and universities?

3.4 REAL TIME DATA CLASSIFICATION FOR QoS IN CC ACADEMIC USER

The data collected in the current study is quantitative and continuous in nature. Quantitative data is mainly numeric in nature and can be analysed statistically. The data is continuous when it is measured on an interval scale and use of Likert scale

was implied for current project survey**.** Responses do not contain a precise value but the degree of accuracy or satisfaction as experienced by the respondents. Methods used in data collection can include experiments, observations, interviews or surveys, which can be sent through emails or personally administered (Sawyer, 2009).

The users who have been targeted for data collection in the current work are the students pursuing degrees in science stream and faculty of state universities and colleges and they must have the experience of using cloud computing applications and services for their studies. The information was collected using an online survey instrument. Survey is a well-organized data collection method through which data can be gathered for carrying out quantitative research. The survey instrument was selected and modified by framing questions based on the variables selected for QoS in CC quantitative analysis. For the collection of data in the current work, the surveys were sent by mail and email to the selected educational facility and were even contacted to confirm their participation by telephonic conversation. Since previously it has been a standard practice by several researchers to use emails and websites forms to collect survey data for studies involving QoS in CC (Creswell, 2003).

The present research work incorporated a descriptive research design to identify the pattern across the population targeted for the research and answer the questions about what, where, when and to what extent. The description of data obtained after subjecting the data through descriptive analysis makes the researcher aware of the mental status of the respondents and they can utilize this information to formulate hypothesis and identify and diagnose issues for further study (Showkat & Parveen, 2017).

3.5 REAL TIME SURVEY INSTRUMENT SELECTION FOR QoS IN ACADEMIC CC USERS

The real time survey instrument selected for the current QoS data collection is founded on the SERVQUAL model. The selected variables were from dimensions of performance that relate to QoS runtime, QoS functionality, and its demographic influence factor. The questions were framed keeping as a base the five variables (tangibility, reliability, assurance, responsiveness and empathy), identified for the current study. Questions based on demographic factors like age, qualification, income, gender were also included in the survey instrument. The responses to the questions are measured using the 7-degree options as recommended in Likert scale as designed by Brown, (2011). The real time data collected is then used to test each stated hypothesis. The data has been collected by use of a survey which was designed in the form of a questionnaire format for data collection was analysed to answer the research questions. Thus, aim was to reach a decision for finding out whether there exists any difference between the service quality expected by these users and the service quality actually experienced by them while using the cloud computing applications and services for their education.

Progress for next step in the study was towards identification of higher education institutions to execute the QoS survey. The survey instrument was then shared through emails and Google drive. The main aim was to obtain the real time input from the academic participants involved in higher education and their QoS experience with CC. The survey data of the sample academic population thus helped progress towards creating a master excel file for the next step of quantitative analysis.

3.6 ACADEMIC HIGHER EDUCATION POPULATION SELECTION FOR QoS AND SURVEY SAMPLING

In a quantitative research design, population comprises a specific class of people from which samples are taken for measurement in a study. It is not possible to target

the whole population, so samples are taken from the population to include in the study (Loeb, Dynarski, McFarland, Morris, Reardon & Reber, 2017). The target population in the current study includes the students and faculty of science stream as they require software and statistical tools for their studies and thus, they are more acquainted with the cloud computing applications and services available for them at their university or colleges. Students and faculty from five colleges and universities who met the above stated criteria were targeted for the current work. The identified and selected colleges and universities were: (1) Banaras Hindu University, Varanasi, (2) VES College of Pharmacy, Mumbai, (3) Jawahar Lal Nehru University, Delhi and JIMS Engineering Management Technical Campus, Greater Noida and (5) State University of New York for international comparison. The institutes selected were situated at different regions of India to make an analysis whether the difference in geographical locations in India shows any difference in the QoS expected and QoS experienced by academic users from higher education sector.

Loeb et al., (2017) propagated that sampling is important for a research study as it consists of a statistical representative of the target population that can be applicable in answering the undertaken research questions which are designed for understanding the challenges In the current work, only those students and faculty were targeted who were involved and including those who had sufficient experience in using the cloud computing services that was being provided through the management of their college or university for their research work or study. In addition, for comparing the QoS expected and experienced by the university users of higher education to an international level, responses were also taken from the science stream students of State University of New-York (SUNY), USA. This institution was selected as a benchmark as the students in this public university in USA are a good representation of the users of cloud computing services, and, for comparing and assessing the quality of the cloud computing services in India with international standards.

3.7 SURVEY INSTRUMENT DESIGNED FOR REAL TIME DATA COLLECTION

The survey instrument for the current work was designed keeping in focus the SERVQUAL instrument which is multi-item and used extensively by the researchers through several years towards evaluation of QoS expected and / or QoS perceived by the consumers in several areas like field of management, science, medical etc. In SERVQUAL, the 22 questions were divided according to the five service quality dimensions as finalised in this study, and were used to identify and measure the gap that likely is missed for analysis when the QoS expected by the users is compared to the QoS actually experienced by them. The responders were asked the same set of questions separately for their expectations about the cloud computing service provided to them and another set of same questions for measuring the experience they had while using those cloud computing services. The answers were assigned numerical values and the weighted scores were calculated to find if there is any gap between them (Parasuraman et al., 1988).

The survey instrument developed for collecting the data in the current work was tailored as per the requirement. It contained overall 28 questions established on the 5 variables identified (empathy, tangibles, reliability, responsiveness and assurance), asking the user about the service quality they expected while using the CC services and the QoS that they experienced while using them. All the answers were measured using a seven-point Likert scale, as developed by Brown (2011). It started with number 1 indicating that the real time academic user of CC user strongly disagrees meaning that the level of satisfaction was very poor and 7 indicating that the user strongly agrees which means that the level of satisfaction was very high. Moving from 1 towards 7, the increase in the level of satisfaction can be marked with 4 acting as the level of average satisfaction. Also, there was a question in the experience section of QoS survey, for getting the response about the overall service quality experienced by them while using the cloud computing

services. In the end, there was a separate section for demographic data including the user's academic institution, highest qualification, age, income and gender.

3.7.1 Pilot study to confirm real time QoS survey instrument selection

To check the viability of the work and survey instrument, a pilot survey was conducted in JIMS Engineering & Management Technical Campus, Greater Noida. The finalized survey instrument was given out to possible CC users in University associated library. Pilot Study was conducted to test the survey questions structure as to improve its quality and to get initial data to conclude that if the research subject is plausible under given conditions. Following methods were used in this study. The findings of pilot survey analysis on the real time use of CC by JIMS academic users has been reported recently by the scholar.

The main objectives behind conducting Pilot study were to know answers to the following concerns:

1. To find whether the survey is easily accessible to the user.
2. To know whether the questions asked in the survey are appropriate according to the user.
3. To know if the survey questions are clear to the user.
4. To find if the language used in framing the survey items can easily be understood by the user.
5. To find out whether the structure of the survey is okay or not for the user.
6. Any other issue regarding the survey items.

   There were only minor suggestions provided from this the pilot survey regarding the framing of two questions which was incorporated in the survey instrument to make it error free and unambiguous.

3.8 RELIABILITY AND VALIDITY OF THE SURVEY INSTRUMENT

There can be a difference in the factors like customers' requirements, expectations and experience about a particular service when observed from the management and the provider as compared with the customers. These differences are termed as gaps and can be measured by using the SERVQUAL model. As stated by Buttle (1996) , SERVQUAL is discussed and used by many researchers in a variety of industrial and commercial settings only after 3-4 years of its publication by Parasuraman et al., in 1988 including tyre retailing, hospitality, architectural services and many more. Over the period of last many years, SERVQUAL has been altered according to the requirement and used for assessing the service quality in various industries and organizations like e-retailing, healthcare, education, police service, tourism, and many more fields (Sawyer, 2009). They have adapted the SERVQUAL base model and done the variations to suit their research or measuring the service quality provided and the satisfaction of the customer and to find the gaps between the expectations and perception of the service as per the customer [Buttle, 1996). From all these researches we can conclude that SERVQUAL instrument has been widely used by the researchers for measuring and analysing the service quality. It is a reliable tool and can be used in the present work for measuring the service quality of the CC users.

3.9 SUMMARY

The real time study methods, research questions were finalized and instrument for the survey was selected. This was performed based on previous studies and various studies conducted in the QoS area related to CC users.

CHAPTER 4: IMPLEMENTATION OF PROTOCOL

4.1 INTRODUCTION

This chapter details up on the main steps as performed after the for optimum tools of research methodology were finalized. The implementation of the selected procedure then leads to progress towards the next step for the current evaluation of QoS in academic CC users from higher educational Universities.

4.2 STEP 1: SAMPLE DATA SELECTED FOR REAL TIME QoS

4.2.1 Criteria for SAMPLE size selection for the study

In this study it was followed as per sample size calculator to achieve 2 % error with 95% confidence level. Considering an assumption that general class size is around 40-44 students, which was calculated by the online posted student numbers and students and faculties assigned to each major subject area. Therefore, based on this idea, it was calculated that it is optimum to include for each university survey almost 43 students out of 44 students in each class.

QoS survey data size was determined by implementation of an online calculator application: https://www.checkmarket.com/sample-size-calculator

The sample size was increased after the pilot study for the current work concluded that selection of parameters for QoS in CC for students and academicians was

optimum. Thus, progress was achieved by including additional real time QoS survey data to reach 238 in total CC users at higher educational Centre.

4.2.2 Selection of Higher Education Centre's

The view of end users of Cloud Computing is critical in-order to provide the specific judgement about the QoS considered and with no other factor being allowed to influence it, as per Parasuraman et al (1991, 1996). Indian and International Colleges and Universities were selected when they matched according to the criteria outlined in the objectives section. Students of science stream who were acquainted in using the cloud computing services were selected from the state-run colleges and universities of higher education. It was decided to compare results with international university at SUNY (State University of New York) USA, due to its high profiling in cloud computing usage. SUNY was used as a benchmark for the comparison of the service quality for Indian students. Our study aimed in comparing outcome to the best model available, and to format a model which can transform Indian Academics at global level. In addition, most of the Cloud computing like IBM, Google and Microsoft are based in the USA, a factor that was considered as independent in this study.

4.3. QoS VARIABLES SELECTION

Variables for assessing QoS were selected after ***extensive literature background*** on similar higher education study articles. Data was categorized as qualitative (Ordinal data). Further, theory of statistical model's data mainly constitutes an independent and dependent variable used for the statistical model derivation (Parasuraman et al., 1996).

In the current study variables were classified as:

(i) Independent variables

a. Institution administration or management

b. IT support services at Center & effective Security
c. Cost reduction in Cloud Computing services by its contractors

(ii) **Dependent variables for QoS in CC and its adaptation.**

In the current study, the questions in the survey instrument were designed based on the dependent variable. It is a continuous variable as the value was dependent on the end user and was collected from 238 respondents for the QoS of CC applications by the survey instrument finalized that addressed the challenges of QoS expected by the users and the QoS experienced by them.

The 5 variables identified for the current work and their explanation, can be outlined is as follows:

Empathy: In real time data for QoS this variable relates to the provision of kindness and private concern towards the CC users at higher education Universities.

Responsiveness: In real time data for QoS, this variable concerns the tendency to help and relay immediate attention for software needs or other services required by CC users at higher academic centres.

Assurance: This variable selected relates to the expertise and assistance of convincing and making belief that comes from the CC employee as well as administration of higher education who have selected the CC contractor, to give the best to the CC user at the higher academia level,

Reliability: This variable is a measure of the capability of CC services that they are conveyed to the higher education CC user with extreme trust and as per their desire and need.

Tangibility: This variable is the measures of CC users at higher academic level as to their approach to adapting to the visual impression of the CC

setup in a physical environment, such that they are able to also be comfortable personally while using CC services at that specific facility.

The above mentioned 5 variables were selected for understanding the QoS in the current project and were incorporated in the survey instrument selected to carry out data collection. This survey apparatus was intended for developing a prototype model to determine the QoS of CC users from higher education level, which included their expectations and experience in CC services, and was constructed on the SERVQUAL scale (Parasuraman et al., 1991, 1996).

The following Table 4.1 further summarizes the variables in relation to the challenges that occur but are not considered some important criteria for implementation as to improve or diminish the existing problem also termed as GAPS in CC services for this specific class of CC users.

Table 4.1 The SERVQUAL Dimensions, Items, and Understanding GAPS

Items	Quality dimension	Expectations (Ei)	Experience or Perceptions (Pi)
1	**Empathy**	End user **will have** special attention to their needs of CC use as well get individual attention from the CC contractor or management.	End user **gets** special attention to their needs of CC use, and gets individual attention from the CC contractor or management.
2	**Responsiveness**	Users **will receive** prompt services with no delays on problem solving of CC services from the CC administration or contractor.	Users **always receives** prompt services with no delays on problem solving of CC services from the CC administration or contractor.
3	**Assurance**	End user **will feel** safe and confident interacting with CC administration.	End user **feels** safe and confident interacting with CC administration.
4	**Reliability**	Prompt and desired services **will be** delivered for use of CC in trust to end user.	Prompt and desired services **have been** delivered in trust to end user.
5	**Tangibles**	Academic Center w**ill** have Visual and modern appealing setup and impressive materials for CC.	Academic Center **has** Visual and modern appealing setup and impressive materials for CC.

Reference: Adapted from Parasuraman, Zeithaml, and Berry's (1991) 'Refinement and Reassessment of the SERVQUAL Scale.'

The SERVQUAL instrument selected for present study is based on gap theory that was derived by Parasuraman et al. (1991) which implicates that magnitude of customer experience from higher education alias perception of QoS is directly indicated by the variation calculated between the customers' expectations as to the perception of the actual service when rendered. It is summarized in Figure **4.1**.

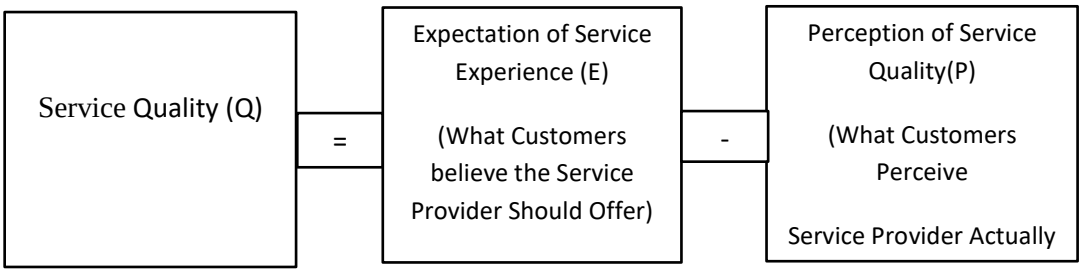

Figure 4.1: A Method for determining the Cloud Computing QoS in higher education

Several modifications and additions have been performed on the model initially proposed by Parasuraman et al. (1985). It introduced the service quality model which was based on the concept that customers' assessment of service equality is the final paramount. The **Figure 4.1**, showing the QoS as the value obtained from (Expectation minus Experience), has been used as an indicator to pinpoint which specific dimension is lacking intervention in technological way and can be modified for improvement. This equation has also been adapted in the present study to understand the level of gap in QoS which academia is facing.

4.4 CLOUD COMPUTING STUDY ROUTINE REQUIREMENTS

The requirements for an End user and its Educational Institution inclusion for its CC performance evaluation are listed below:

- Legible Contract of Cloud computing service provider through Management center of University or College
- Essential CC Services offered to students/faculty, should be inclusive of the following services

- Individual identity login and its security maintenance
- Access to on-line application for course registration for specific study
- Access to attendance records, exams, mark-sheets/results
- Access to class blogs, forums
- Access to collaborative tools enabling resource
- Access to Library database search tool
- Access to Computers in Class /Computer Labs
- Onsite/online CC technical problem solving inclusive (for individual login) and its management
- As an End user, Students and Faculty currently engaged in study in undergraduate/graduate/postgraduate programs/research.
- Notification alert in case of system breach
- Updates as required for software and hardware to function CC systems optimally

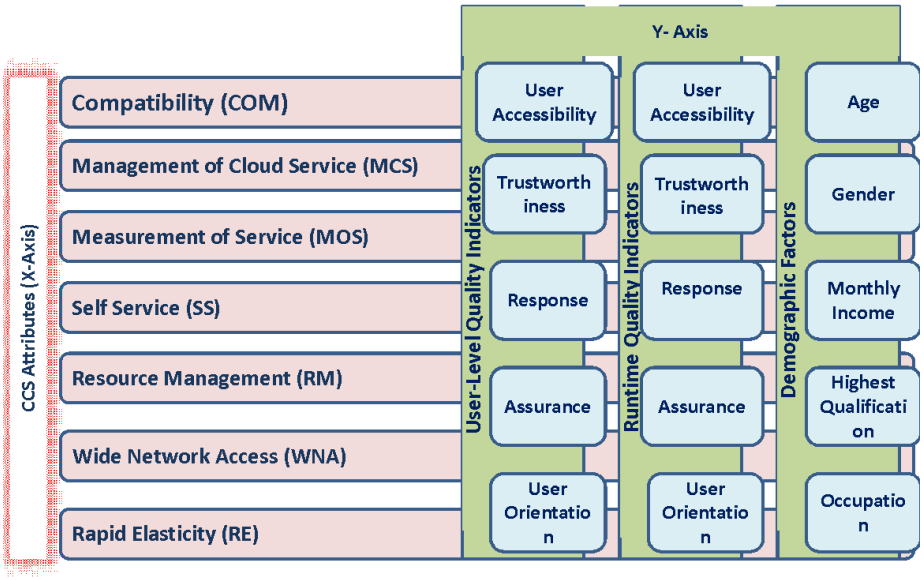

Figure 4.2: Shown above is the architecture of Innovative CC academic User-Centric QoE Model

All the above-mentioned variables are aligned in a specific structure **(Figure.4.2).** This helped during the prediction of the logistic gap model, such that it was possible to make efforts towards understanding the effect of all the 5 dimensions selected, cumulatively as well as individually using the SERVQUAL instrument. Therefore, this approach was an important factor in creating a meaningful Quality of Experience model for the specific users under consideration in this study.

Study related this model in Figure 4.2 to investigate the challenges existing as to the adaptability and use of CC in academic libraries. It was done during the pilot study that aimed at evolving a standard apparatus in order to calculate the QoS as understood by the specific users of the University, which would consider reviewing other factors in CC structure improvement.

4.5 STEP 2: RESEARCH DESIGN: SURVEY QUESTIONS AND HYPOTHESIS TO QoS

4.5.1 Survey Instrument Design for real time capture of Data

The survey instrument for the pilot survey consisted of two parts.

- Part-I considered the known academic users of CC and concerns about the QoS expected and QoS experienced by the user.
- Part-II focused on potential users in higher education (libraries, students etc.) who have yet to adopt cloud computing platforms or services.

The survey instrument contained questions for each of the five variables identified; 5 sections with 5 subsections in both QoS expected and QoS experienced by the users of cloud computing applications and services of higher education.

Universities and colleges with reputed credentials were subjected to this quantitative study in-order-to explore the possible cause of difference or similarity in cloud computing services used by the population of the higher study sector. *The*

questions formatted in synopsis were realigned to relate well to the answers from data collected from this study.

4.5.2 Research Questions for real time academic CC users

Research questions were designed to address what service quality were expected (part A), and how was their usage (part B), and then put into numerical value to identify (part C) and to measure by statistical analysis (part D) to find the differences or similarities in "QoS" by the end users of higher studies directing to the prediction of the QoS logistic Gap model.

Research questions were based as per the following sections to bring out clearly the concept of the current work.

A) Current Status or actual Experience of QoS by the academic populations of the CC applications provided to them by the college or university management at the Educational Center.

RQ1: What is the existing environment regarding QoS in CC applications in the area of higher online education at varied Universities?

RQ2: What are the present protocols to meet the educational needs of academic users and are they sufficient and efficient?

B) Targeting end users Expectation of QoS by the CC customers of higher academic setting of the CC applications provided to them by the college or university management at the Educational Center.

RQ3: What are the current requirements regarding QoS in CC setup for use by the population of higher education?

C) Data Analysis together with Variable Identification (using SERVQUAL model-grouping in 6 dimensions: -Empathy, Assurance, Responsiveness, Tangibles, Reliability and overall QoS)

RQ4: While monitoring online learning which is in demand in academia, how can we identify and quantify the variables defining QoS in CC and its various aspects together with targeting how it can be formalized further for hypothetical grouping and assessment?

D) Deliverables (directed to QoS Model prediction and pointing to its differences and similarities as found within Educational population as well as between National and International / USA Educational Institutes)

RQ5: How can QoS be guaranteed for CC services proficiently?

RQ6: How can we propose a future framework / prototype model for certifying the quality of CC at all levels?

RQ7: Can we have more significant advantage in QoS management through the proposed prototype model?

4.5.3 Main Research Questions for real time data collection

Based on all the above research questions, two primary research questions were framed and analysed in the current study:

1. Does any difference exist between the QoS expected by the academic users' and the QoS experienced by them while using the cloud computing applications and services? (Focusing on the state- run colleges and universities in India)
2. Is there any difference between the QoS expected and experienced by the Indian and the international users of the higher education sector, in state run colleges and universities?

To approach our hypotheses, the above-mentioned research questions were addressed during the current study that helped approach how to predict a conceptual logistic QoS metrics prototype model. This would help identify the quality defining metrics and their relationship to evaluate them through real time data for different quality attributes for cloud computing applications with emphasis on real time learning in the higher education population. First, the variables were identified, as to which are associated with providing QoS in CC services. Second, a comprehensive real time data sheet made in excel was attained. Finally, all results were analysed to help design a service computing architecture to help progress towards a predictive logistic QoS model.

4.5.4 Hypothesis Statements

Hypothesis statements were framed after identifying and selecting metrics for the proposed QoS logistic gap model. The hypothesis statements were based on the identified specific variables and their role in affecting the QoS in CC applications and services from the users' perspective.

The following hypothesis statements were formed for all the variables selected for the study i.e. empathy, reliability, tangibles, responsiveness and assurance. Both Null hypothesis and Alternate hypothesis was framed for each of the variable to clearly assess the QoS.

Hypothesis I (H1)-*Empathy:*

H null (H_0 1): Empathy level was same for QoS expected and QoS experienced by academic users of CC

H alternate (H_A1): Empathy level was different for QoS expected and QoS experienced by academic users of CC

Hypothesis II (H2)-*Responsiveness*:

H null ($H_0$2): *Responsiveness* level was same for QoS expected and QoS experienced by academic users of CC

H alternate (H_A2): *Responsiveness* level was different for QoS expected and QoS experienced by academic users of CC

Hypothesis III (H3)-*Assurance:*

H null ($H_0$3): *Assurance* level was same for QoS expected and QoS experienced by academic users of CC

H alternate (H_A3): *Assurance* level was different for QoS expected and QoS experienced by academic users of CC

Hypothesis IV (H4)-*Reliability*:

H null (H_0 4): *Reliability* level was same for QoS expected and QoS experienced by academic users of CC

H alternate (H_A 4): *Reliability* level was different for QoS expected and QoS experienced by academic users of CC

Hypothesis V (H5) -*Tangibility*:

H null ($H_0$5): *Tangibility* level was same for QoS expected and QoS experienced by academic users of CC

H alternate (H_A5): *Tangibility* level was different for QoS expected and QoS experienced by academic users of CC

Hypothesis VI (H6) - Pertains to the difference in QoS as expected and experienced by the Indian and international users.

H null ($H_0$6): QoS expected and QoS experienced by academic users was the same at the Indian and International level.

H alternate (H_A6): QoS expected and QoS experienced by academic users was different at the Indian and International level.

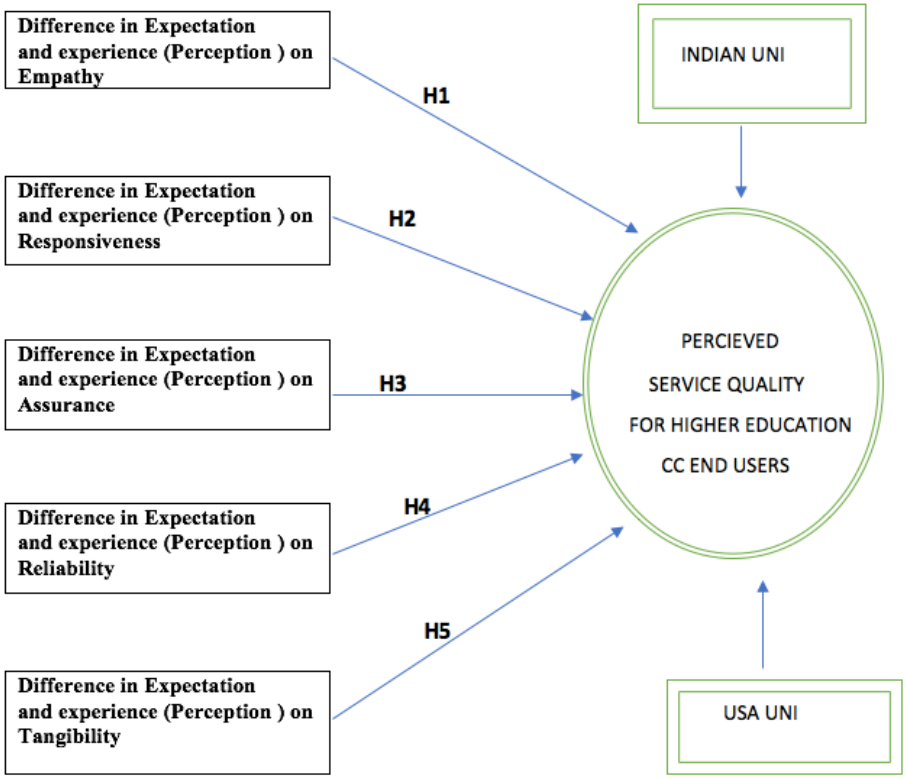

Figure 4.3: QoS Model showing the research Hypothesis being tested to be related to perceived service in National (Indian) and International University (USA)

4.6 STEP 3: DATA COLLECTION AND ORGANIZATION

National and international students at higher education level are now exposed to different levels of cloud computing services. Our survey was based on their daily interaction with cloud computing applications and services which included online admissions form and data submission (which was then analysed by cloud service software to assign admission to specific degree program), use of google doc (which is used for assignments, communication projects and exams and marks visualization before the hard copy is obtained by student).

Data was obtained from survey from higher education centres in India and USA via email correspondence. The survey questionnaire was sent to the respective University administration, and students and staff were contacted, who then volunteered to respond to this survey for QoS at their centre. The Educational institutions selected were ranked as the top most in academics, which are known to make efforts to keep the technological infrastructure requirements updated. Students who filled the survey were currently enrolled in bachelors, master or Ph.D., degree programs, to be included in this study. *Only the completed survey forms (from the listed number of students in the table below) received in a timely manner were included and put in EXCEL for this study.

4.7 STEP 4: DATA QUANTIFICATION AND STATISTICAL TOOLS

Data Collected in this study includes the responses collected from the **subjects who are bachelors or masters' degree students, mostly who have selected science subjects** and was achieved by developing a SERVQUAL survey instrument, which includes quantifying the responses of the end users based on defined variables and then subjected to statistical analysis using ANOVA (Sawyer, 2009). The survey responses were manually entered in an excel data sheet together with use of an on-line calculator to calculate the output results.

The study is inclusive of independent and dependent variables. Independent variables here are Institution administration or management, IT support services at centre, effective security and cost reduction in cloud computing services by its contractors. While cloud computing selection and its adaptation has been considered as the dependent variable in this research study.

Real time data obtained from survey and values from each section (28 in expectation of Cloud Computing QoS variables and 28 in experience of QoS variables, 1 for overall QoS experienced and 6 for demographic data) of questionnaire, which were averaged and statistically quantified for Descriptive Statistical Analysis and for inference by one-way ANOVA.

4.7.1 Data Analysis Methods

Descriptive analysis for quantification of the variables

The goal of the subjecting data to quantitative research is related to in-depth understanding of characteristics and patterns across the population of interest. After descriptive analysis, it is easy to know about the conditions and circumstances of the data under observation. Descriptive analysis is a required and necessary component of a high-end quality research work (Showkat et al., 2017). The descriptive analysis of the data was done by subjecting the data to Kolmogorov – Smirnov test to find the mean, median, mode, standard deviation, skewness and kurtosis of the data. The data was subjected to Kolmogorov – Smirnov online calculator. It also gave the K-S test statistic value (D) and p-value to find whether the data meets the assumption of normality or not. The real time data from the survey collected and classified for all the five variables was subjected to the K-S test. The results after the quantification of data proved the viability of the data and variables for the current work.

4.7.2 Assumptions of ANOVA (Analysis of Variance)

For inferential conclusion, data was subjected to ANOVA in the current work, which has the following assumptions:

(i) The data should be normally distributed.

(ii) There should be homogeneity of variance called, homoscedasticity.

To meet the assumptions of ANOVA, the data collected in the current study, was subjected to two statistical tests as described below. The quantification and analysis of the data obtained was carried out by using the following statistical tools:

1. **Levene's test of Homogeneity of Variance:**
   Levene's test is a statistical test used to assess the equality of variance for variables calculated for two or more groups (Heinze & Dunkler, 2017). Levene's test is used to quantify the data to find if the samples have equal variance. If there is equal variance across all the samples, it is called homogeneity of variance. The data collected was subjected to this test to analyse the fitness of the variables identified for the current work. The variables were tested in pairs so that all can be assessed for equality of variance (Gastwirth et al., 2009).
2. **Linear Regression and Correlation Analysis**
   To further satisfy the assumption of ANOVA, the data was subjected to Linear Regression and Correlation Analysis using Spearman's Correlation co-efficient.

The statistical concept of regression and correlation is used to evaluate the relationship between two continuous variables which focus on association between the variables, the value of one variable predicting the other and the strength of association. The Spearman's correlation coefficient (ρ, also signified by r) is a non-

parametric test used to measure the strength and degree of association by analysing the monotonic relationship between the two variables. (Wang, 2017).

After descriptive analysis and Levene's test, linear regression was done to test the relationship between the 5 selected variables for the present study together assessing the strength of their relationship by implementing Spearman's correlation coefficient to evaluate the strength of the relationship among the variables, as similar approach has been practiced by Klug & Bai (2015) 4.

4.8 ONE-WAY ANOVA FOR INFERENTIAL CONCLUSION

For testing the hypothesis, inferential statistical techniques are used and on that basis, it is decided whether the hypothesis are accepted or rejected. This process of analysis which follows description of data to provide conclusive results is known as inferential analysis. Analysis of Variance (ANOVA) is a useful statistical tool for drawing inferential conclusions for more than one group (Schneider et al., 2010). While conducting ANOVA, the means of several samples are compared to find if there is any significant difference between their means by doing the analysis of the variance. The ANOVA test procedure compares the variance between samples (Sum of Squares for groups, SSC) to the variance within samples (Sum of Squares for Error, SSE). The ANOVA F-value rejects the null hypothesis that the mean responses are equal in all groups if SSC is large in comparison to SSE (Zou, Tuncali & Silverman, 2003).

After the assumptions of ANOVA were successfully met, the data in the present work was subjected to one-way ANOVA for inferential conclusion. One-way ANOVA was selected because the current work is interested in analysing the increased value of the outcome. It is also called a directive test because it has one-way direction not towards both the ways.

4.9 COMPARISON OF QoS IN REAL TIME BETWEEN NATIONAL AND INTERNATIONAL INSTITUTIONS

An effort was directed to understand the QoS calculated by survey for academia population of Indian Universities with International University for QoS (USA University taken as Reference).

For finding if there is any difference between the service quality expected and experienced by the students of Indian colleges or universities and the service quality expected and experienced at the international level, a smaller set of the data was collected from an American university, State University of New York (SUNY). The students or users targeted were doing their graduation in science stream. The American university was selected as their students are well-acquainted with the services of cloud computing and it was taken as a benchmark for comparing Indian scores. The students filled the survey instrument designed for the current study. Then the data obtained was put to analysis by using ANOVA statistical tool.

4.10 DIMENSIONS FOR QoS ASSESSMENT WITH SERVICE QUALITY GAP MODEL

Expected Service (ES) – Perceived Service (PS) = Service Quality Assessment Score

Or

Perceived Service (PS) - Expected Service (ES) = Service Quality Assessment Score

As derived from Parasuraman et al, (1985, 1991), and Kar (2016), SERVQUAL scores were defined here as difference calculated between values of mean QoS "Expectation Services" (ES) and experience (or referred also as Perceived) services (PS) for real time case studies, that represented "GAP" that accounts for status of

CC service for academic users of higher education during their educational course enrolment. Shown as calculated in Table 3 below:

QoS Expectations exceed: ***ES < PS****(CC Service Quality is Excellent!!)*

QoS Expectations met: ***ES ~ PS*** *(Satisfactory CC Service quality)*

QoS Expectations not met: ***ES > PS*** *(Unacceptable or poor Quality of CC service)*

The difference or the "gap score" obtained for in either positive or negative value, depends if (ES-PS) or (PS-ES) was applied for calculations. Here in table 3, use of (ES-PS) has been used though the outcome of average SERVQUAL value is the same except being positive and negative. The higher or lower gap score value has a direct indication where the expectations were high, and experience of CC services was unacceptable.

However, if analysis of data from current students is performed yearly, from time to time basis, during their course of study, it would provide a real time improvement measurement score. This can be then used as an indicator to target effectiveness of Cloud services development and improvement for the assigned SERVQUAL dimensions which have acquired unacceptable score values in its previous evaluation.

4.11 SERVICE QUALITY GAP MODEL

In the effort to support the emergence of spectrum of demands and variability in CC academic user class, it is essential to identify critical guidelines. It will help the technological sector to analyse and evaluate related major QoS variables which are recommended by NIST, USA (Ostertagova & Ostertag, 2013).

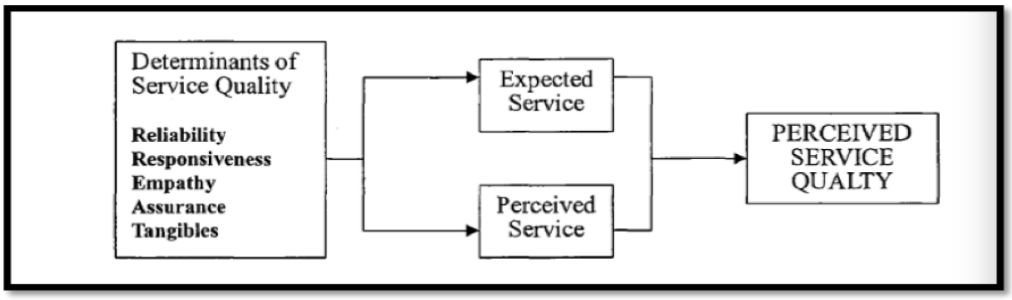

Figure 4.4: Shown are the Determinants of Perceived Alias Experience QoS for the higher education users (Source: Parasuraman et al., 1988)

The purpose of such an approach is to ensure coverage of the QoS of CC under all technological and functional prospects. SERVQUAL, which has been utilized by several researchers incorporates questions that cover QoS evaluation (Parasuraman et al, 1988). The tool targeted at developing a standard model which would be used to measure the academic users' QoS using the selected SERVQUAL instrument, as shown in above Figure 4.4., such instrument is beneficial in understanding the academic challenges for CC.

Taking Gap model as proposed by Parasuraman et al. in 1988 as base, logistic gap model was predicted for the current work, conducted in real time frame. This gap model will help further to evaluate the difference or gap between the QoS being expected by the users of higher education and being experienced by them after using the CC services for higher education sector. The variables selected for the current work will be mapped against the gaps to find out clearly the reasons for the gaps and the possible ways to close them.

4.12 SUMMARY

This chapter summarizes the description of research design, population and sample, designing of the survey instrument, methods of data collection and organization and data analysis statistical tools and methods used for predicting logistic gap model in the current study.

CHAPTER 5: RESULTS AND DISCUSSION

5.1 INTRODUCTION

The current section is composed of the survey reports, analysis, and discussion of the research questions and hypothesis. The current study measures and analyses the real time QoS of CC as expected and experienced by the selected academic users. This CC customer population in current study includes students and faculty of higher education institutes who incorporate cloud computing services and its applications on a regular basis for their course work and research study purpose. The current chapter thus puts forward the results of the current work inferred using descriptive analysis and inferential conclusion. After evaluating if there is any difference between them, the current analysis develops a QoS logistic regression gap model which allows the gaps to be mapped as present in the QoS user-provider architecture. This model can be therefore used for possible changes to remove the identified gaps for better QoS experience for academic users.

The statistical methods and tools used for inferring the results are discussed below

(i) Descriptive analysis which is used to describe data by measuring and identifying central tendency of the data (mean) and the variability of data (variance, standard deviation)

(ii) Inferential conclusion (One-way ANOVA) to establish the goodness of fit of the predictive conceptual logistic regression model for real time QoS of CC for current selection of academic customers defined for our study.

5.2 DESCRIPTIVE STATISTICAL ANALYSIS FOR REAL TIME QoS ACADEMIC SURVEY DATA

The survey data of 238 users collected in real time was subjected to Descriptive Statistical analysis so it can qualify to understand the findings of QoS evaluation.

5.2.1 Defining Measure of Mean, Standard Deviation, Skewness and Kurtosis

The real time survey of academic users in present study data is a continuous type data set, and the measure of central tendency and variance of data is an important determinant for analysis (Klug & Bai, 2015). To test the fitness of data in the current study, it was subjected to descriptive analysis computing its

- Descriptive statistics was conducted using the online Kolmogorov-Smirnov Calculator (Test of Normality).
- "Mean" for the 238 values of survey data of academic users was calculated as the average of the current input data numbers,
- "Skewness" in the current study was determined to measure the asymmetry of the probability distribution of a real-valued random variable about its real time QoS academic survey statistical mean,
- "Kurtosis" in this study of the real time QoS academic data that was checked to determine degree of the "tailedness" of the probability distribution of all 5 selected variables for CC and Standard deviation to find how much the data is deviated from its mean,

The following table shows the descriptive statistics computed for QoS expected, QoS experienced and the difference between them.

Table 5.1: The following table shows the Descriptive Statistics for Variables under Expected and Experienced/Perceived QoS for the Indian Universities academic CC users

QoS	**Variables**	Min	Max	Mean	Std. Dev	Skewness	Kurtosis
Expected	Tangible	1	7	5.36345	0.515038	2.178892	3.616555
	Assurance	1	7	6.2535	0.310655	-4.30307	22.991371
	Responsiveness	1	7	5.0028	0.526594	2.200704	6.086835
	Reliability	1	7	6.61261	0.4677	-2.504234	7.011925
	Empathy	1	7	3.1	1.455935	1.668881	0.946072
Experience							
(Perceived)	Tangible	1	7	3.46218	1.101705	2.117834	2.831709
	Assurance	1	7	2.62885	1.459476	1.943907	1.921469
	Responsiveness	1	7	2.27661	1.46203	2.13477	2.883588
	Reliability	1	7	2.58992	1.379378	2.008396	2.305142
	Empathy	1	7	2.4563	1.53728	2.010374	2.275272
Difference							
(E-P)	Tangible			1.90127	-0.586325	0.071086	0.785146
	Assurance			3.62465	-1.148821	-6.246977	21.069902
	Responsiveness			2.72619	-0.935436	0.065934	3.203247
	Reliability			4.02269	-0.911678	-4.51263	4.706783
	Empathy			.6437	-0.081345	-0.341493	-1.3292

5.3 CONCLUSION OF DESCRIPTIVE STATISTICAL ANALYSIS

The above table (Table 5.1) shows the descriptive statistics of QoS expected and QoS experienced for CC in academic users. The normal range of skewness (asymmetry of data) for normality is defined to be from -2 to +2 and for kurtosis (peakedness of data) from -7 to +7. But ANOVA can handle minor violations of normality and variance if the sample size is large. The mathematical validity of ANOVA is said to be robust in case of violations of normality ranges if the data set is large (> 30) and it can work well even with population distributions that are highly skewed and non-normal with large data set (Sawyer, 2009).

It was observed that the range of skewness of the data for experienced QoS ranges from 1.943907 to 2.13477 and kurtosis from 1.921469 to 2.883588 which is within the acceptable range. For the expected QoS the range of skewness is from -4.30307 to 2.200704 and for kurtosis from 0.946072 to 22.991371 which is above the range but fit for our study as it has a large data set of 238.

5.4 GRAPHICAL REPRESENTATION FOR DESCRIPTIVE DATA FOR EXPECTED QoS AND EXPERIENCED QoS

Histograms were plotted for both experienced and expected QoS survey data using standard deviation and mean to show the spread of data.

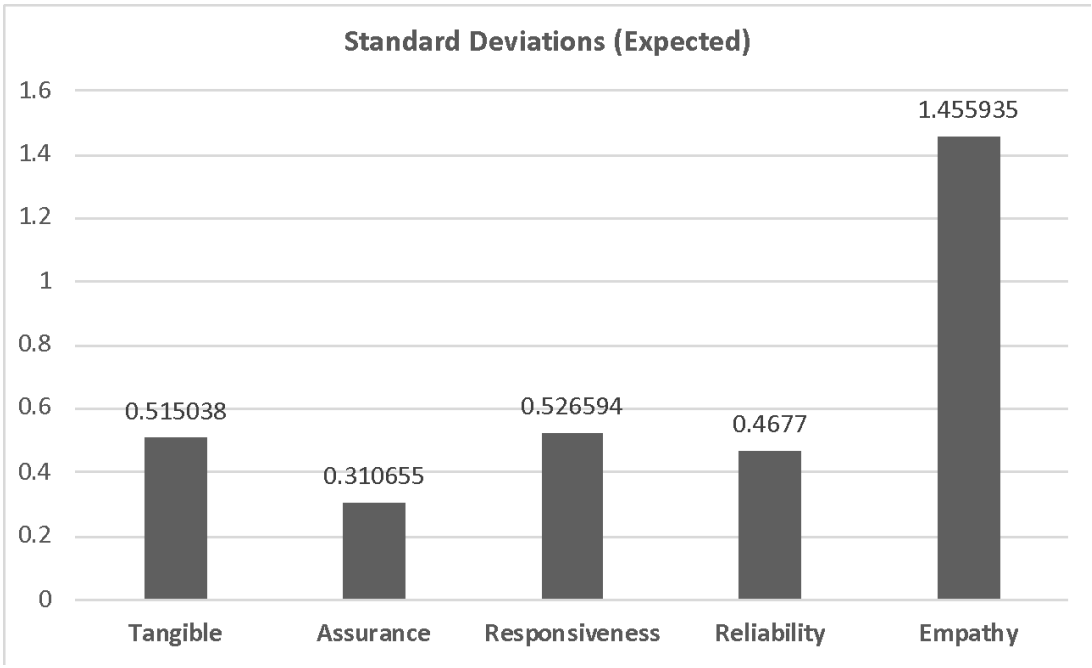

Figure 5.1: Shows the Standard Deviation of Expected QoS for all five variables studied for Indian Universities academic CC User, in real time

In the above graph 5.1 shown, Expected QoS show less deviation from mean which denotes for that in current study that real time survey data had variable values that were closer to the **mean** of expected QoS value.

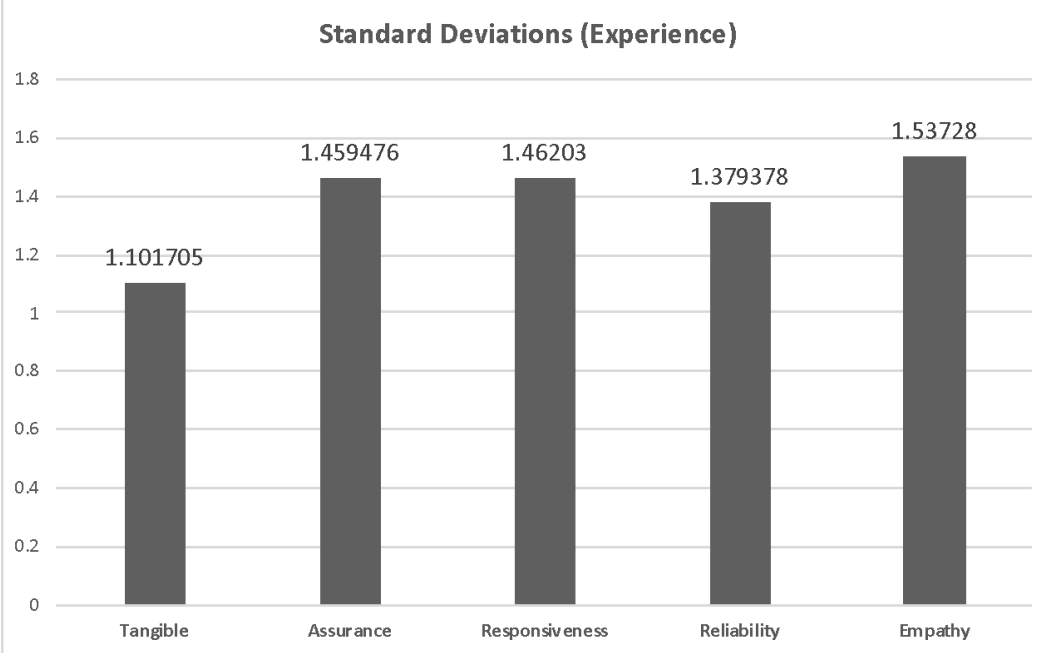

Figure 5.2: Shows the Standard deviation of Experience QoS for all five variables studied for Indian Universities academic CC User, in real time

The graph in Figure 5.2, plotted for experienced data shows more deviation from mean which specifies that the current study real time survey data of QoS variables incorporated values that are spread out over a broader range.

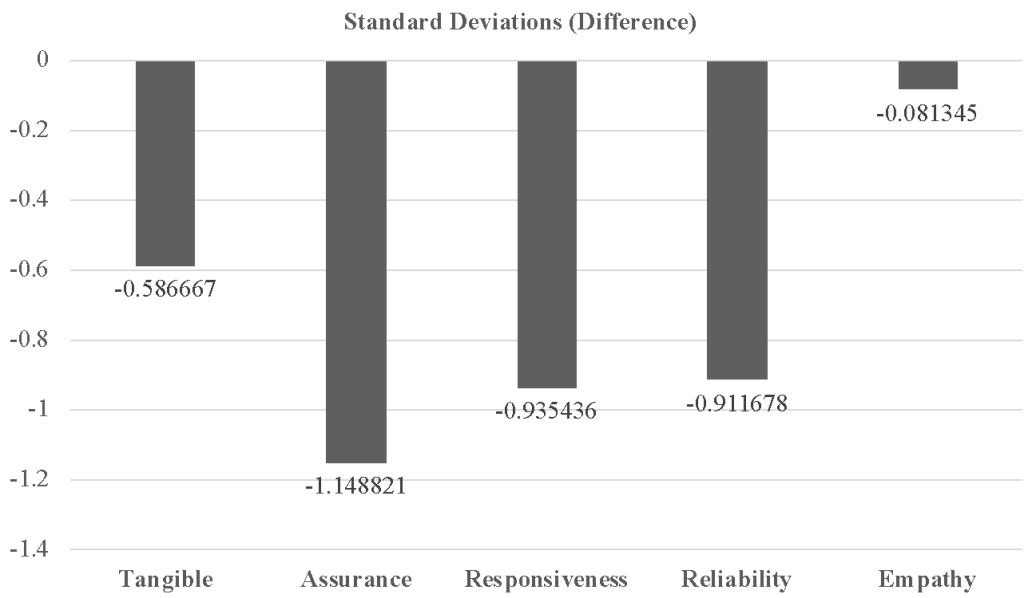

Figure 5.3: Shows the Standard Deviation of QoS (E-P) difference for all five variables studied, in Indian Universities CC academic users in real time

The above graph 5.3 has been plotted for depicting the difference in expected and experienced QoS shows that the spread of data is towards the negative side which describes that the score of values expected was more than the score of values experienced for all the five variables selected for the current study, proving the difference between QoS expected is more than the QoS experienced by the users of higher education, further making the selection of variables and the data collected was qualified fit for inferential analysis of our current work.

5.5 THE QUANTIFICATION OF QoS VARIABLES SUBJECTED TO INFERENTIAL STATISTICS

The stages of quantification of variables for real time data was subjected to "inferential statistics" with the implementation of a statistical method selected called "one-way ANOVA". The stages for the same are as described below:

1) Assessment of reliability and inter-correlation of variables.
2) Logistic Regression analysis to evaluate the relationship between predictor and criterion variables
3) The results thus obtained were used to test the hypothesis proposed H1 to H6 that were developed for real time QoS in academic users for CC and has been stated in detail in Chapter 4.

5.5.1 Levene's Test of Homogeneity of Variance: Statistical assumption requirements met

Levene's test is a statistical test used to assess the equality of variance for variables calculated for two or more groups [Wang et al, 2017]. It was conducted on the pairs of all the five variables and the results showed that some pair of variables met the criterion of homogeneity when these pairs showed non-significance p-values.

Empathy & Reliability, f= 0.53; p=0.4 thus criteria of homogeneity met

Empathy and Assurance f= 0.23; p=0.6 thus criteria of homogeneity met

Empathy and Responsiveness f= 0.12; p=0.7 thus criteria of homogeneity met

Reliability and Responsiveness f= 0.125; p=0.72 thus criteria of homogeneity met

However, half variable pair also did not meet the criteria as shown in **Figure 5.4,** below:

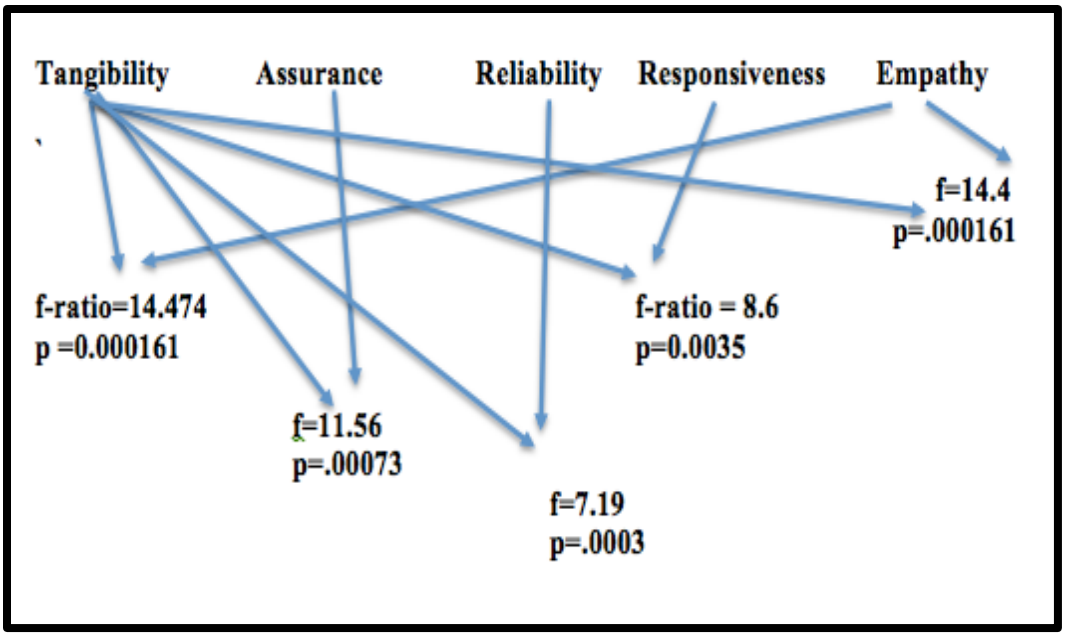

Figure 5.4: Shows Levene's test results on paired variables for QoS in real time Study

According to the statistical reports, ANOVA can be done even if some variables did not meet the criterion of homogeneity of variables as the sample size is big i.e. greater than 40. [Ghasemi & Zahediasl, 2012]. As the current study has a large dataset of 238, assumption of ANOVA was met.

Results indicate from the values depicted in the figure that the requirement of homogeneity was not met as result has p- value showing significance ($p< 0.05$), which indicates that variables have different variances but can be included in the model due to large data set.

5.5.2 Linear regression and correlation analysis for QoS experienced and expected

The goal of carrying out correlation and linear regression in the current work is to analyse and understand the relationship between two variables, by keeping the other three variables constant and fitting a linear equation to observe the data. In the selected dependent variables for our study; Tangibility, Assurance, Reliability,

Responsiveness and Empathy in both Experience and Expectation QoS data of 238 surveys, one of the selected variables was considered as an explanatory variable (predictor) and the other was considered to be a dependent variable. Spearman's correlation coefficient (r), which ranges in value between (-1)and (+1), has been used to indicate the strength of the association of the two variables of the observed higher education CC users QoS survey data in real time present study. Assuming the linear relationship, the regression lines are never precisely perfect for dependent due to influence of independent variables. However, slope of the line in selected 5 variables reported "$R^2 > 0$" and thus adds to the context of relationship between the variables and impacting the outcome alias QoS which can be observed from the following Scatter plots.

A linear regression line has an equation of the form $Y = a + bX$

where X is the explanatory variable and Y is the dependent variable. The slope of the line is b, and a is the intercept (the value of y when x = 0). (Sawyer, 2009).

Regression graphs for the QoS Experience by the CC users

Shown in the following graphs, **Figure 5.5** to **Figure 5.8** are the relationship for Variable data from survey of Experience of QoS. The Regression Graphs confirming the positive linear relationship between the variables as R^2ranging 0.9 to 0.

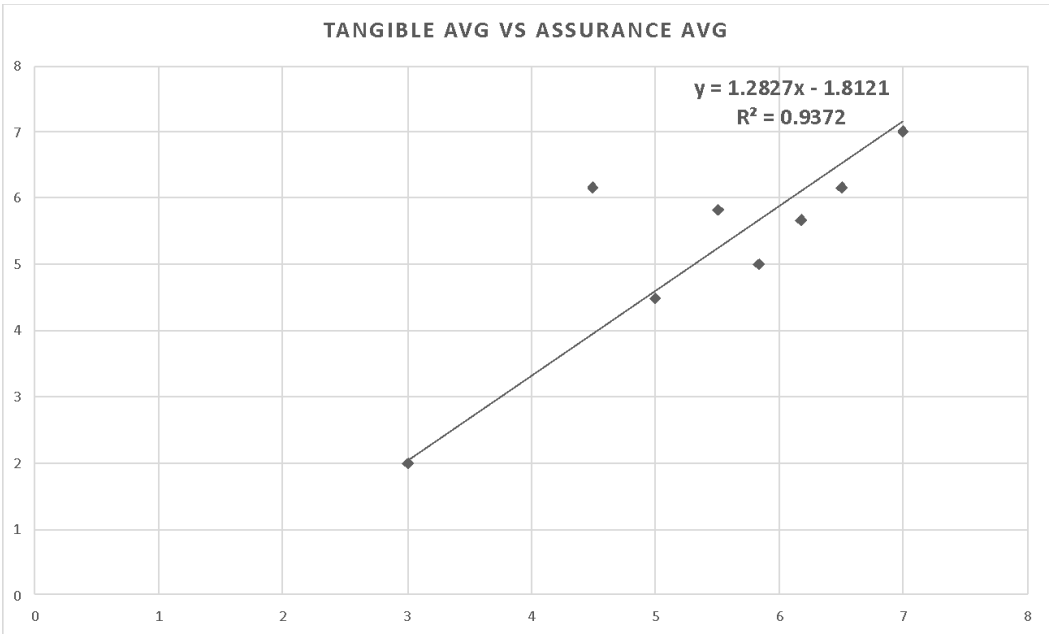

Figure 5.5: Variable in Experience of QoS: Shown for weighted average value of variable Tangible vs Assurance

In the Scatter Plot Figure 5.5, the strong relationship and strength between two variables; Tangible average vs Assurance average is depicted, Using the linear regression line equation;

$$y = 1.2827x - 1.8121$$

$$R^2 = 0.9372$$

The value of R^2 closer to (+1) indicates strong association between the two QoS variables by linear relationship.

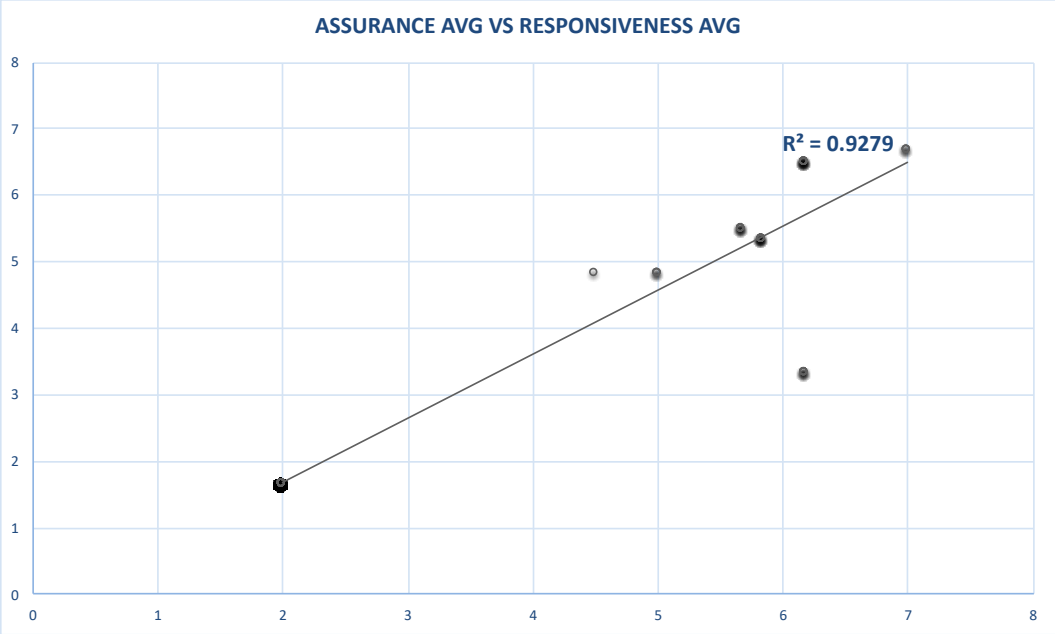

Figure 5.6: Variable in Experience of QoS: Shown for weighted average value of variable Assurance Versus Responsiveness

In the Scatter Plot **Figure 5.6**, the relationship and strength between two variables; Assurance average vs Responsiveness average is depicted, using the linear regression line equation and concludes that they have a positive relation;

$$y = 0.9637x - 0.2544$$

$$R^2 = 0.9279$$

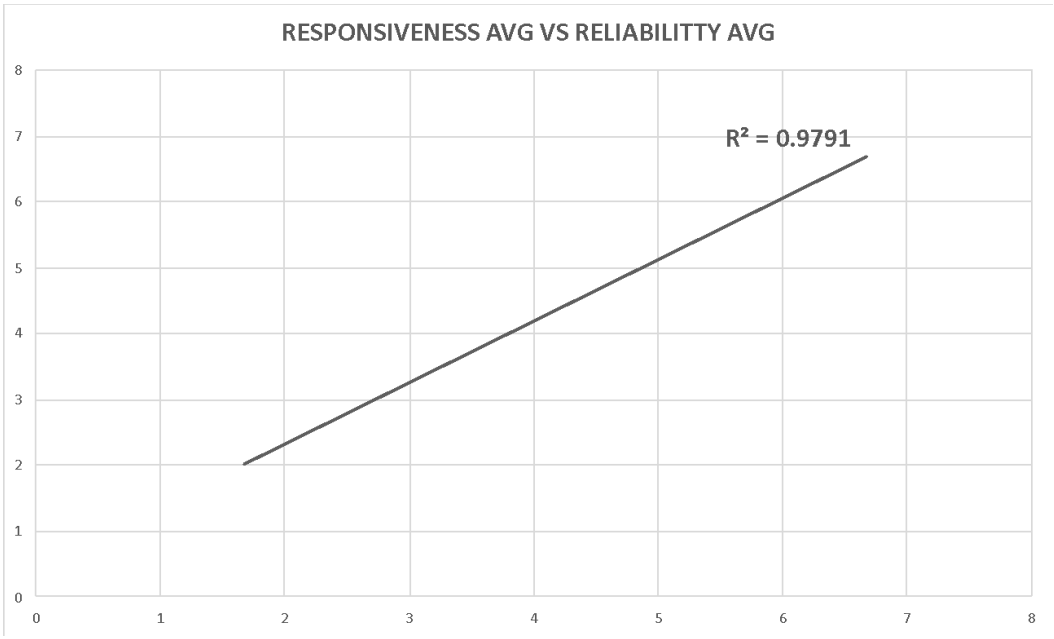

Figure 5.7: Variable in Experience of QoS: Shown for weighted average value of variable Responsiveness Versus Reliability

In the Scatter plot in Figure 5.7, the relationship and strength between two variables; Responsiveness Average vs Reliability Average shows strong association and is depicted, using the linear regression line equation;

$$y = 0.9345x + 0.46$$

$$R^2 = 0.9791$$

The Value closer to (+1), shows that there is a strong linear relationship, as shown in Figure.

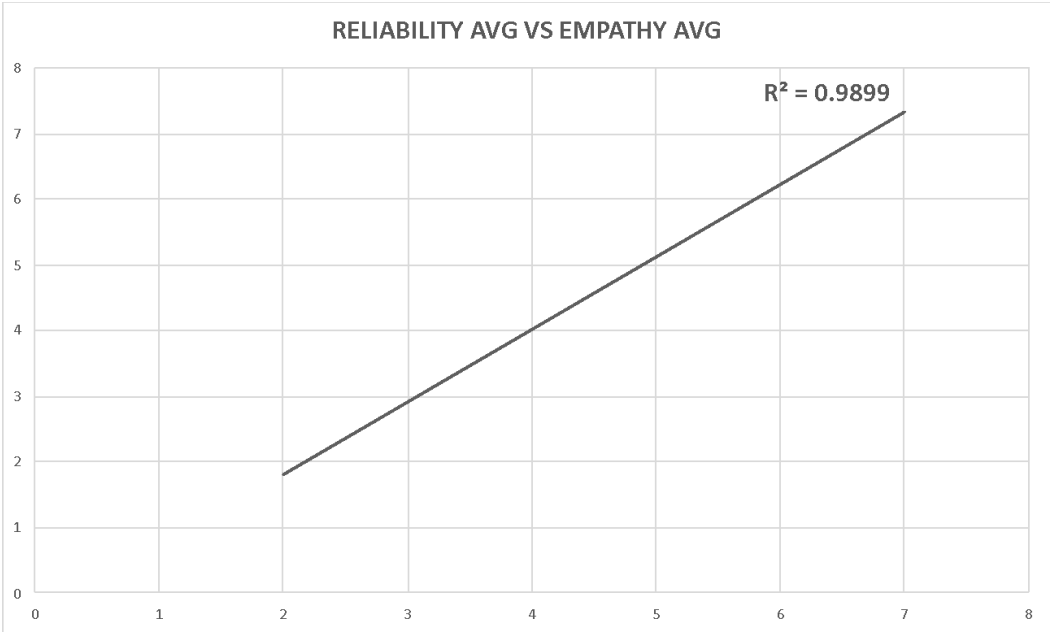

Figure 5.8: Variable in Experience of QoS: Shown for weighted average value of variable Reliability Verses Empathy

In the Scatter plot in 'Figure 5.9', the relationship and strength between two variables is strong. Reliability average vs Empathy average is depicted in graph, using the linear regression line equation;

$$y = 1.1088x - 0.4155$$

$$R^2 = 0.9899$$

The R square values (from regression graphs show) R^2 value range from 0.92 to 0.98 which indicates strong positive association between the above plotted QoS variables for QoS experience.

Regression graphs for the QoS Expected by the CC users

The following **Figure 5.9 A to Figure 5.12** are plotted for variables for QoS Expectation data subjected to the Regression analysis. Graphs confirming there is a less direct linear relationship between the variables as $R^{2\,\#}0$, except **Figure 5.12** where it is a linear relationship.

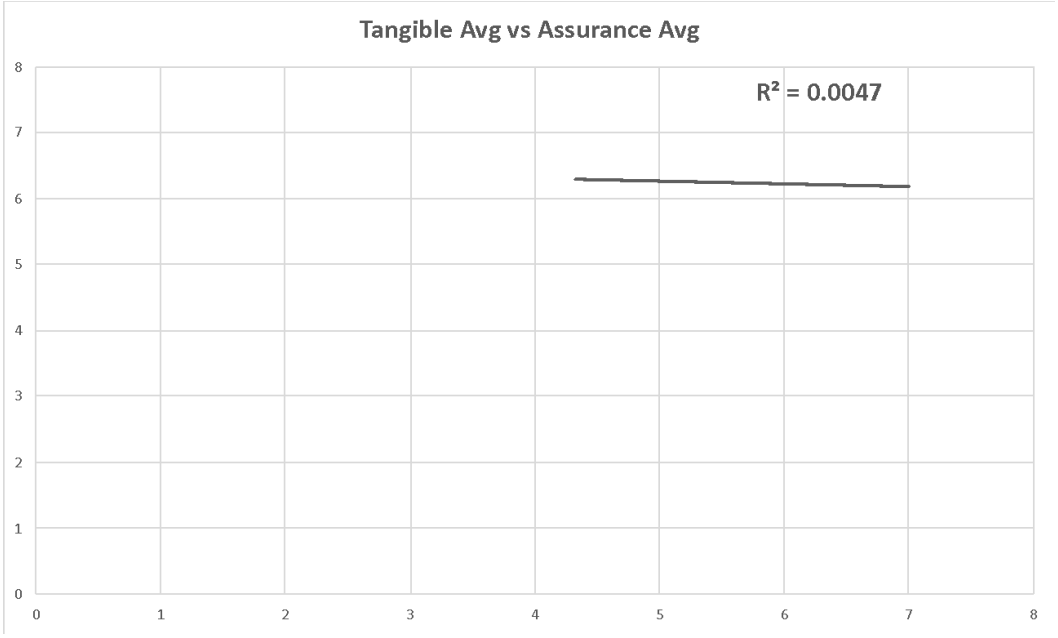

Figure 5.9: Shows, QoS Expectation variables, Tangible vs Assurance data subjected to the Regression analysis

In the Scatter plot in Figure 5.9, the relationship and strength between two variables is weak since Tangible average vs Assurance average shows $R^2 = 0.00474$

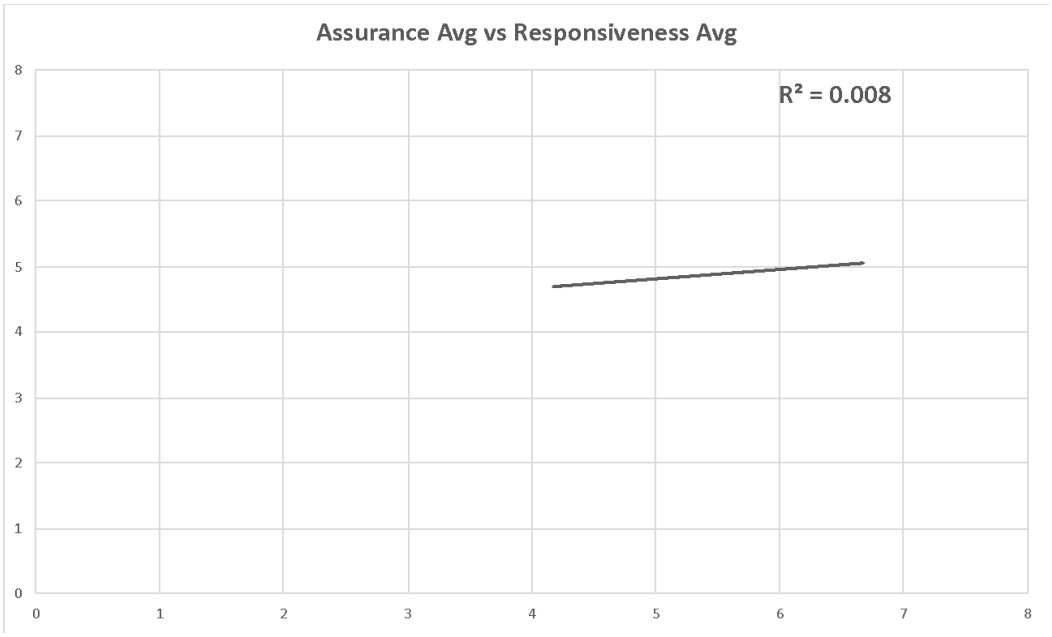

Figure 5.10: Shows, QoS Expectation variables, Assurance vs Responsiveness data subjected to the Regression analysis

In the scatter plot Figure 5.10, the relationship and strength between two variables; Assurance average vs Responsiveness average is depicted, which shows $R^2 = 0.00867$

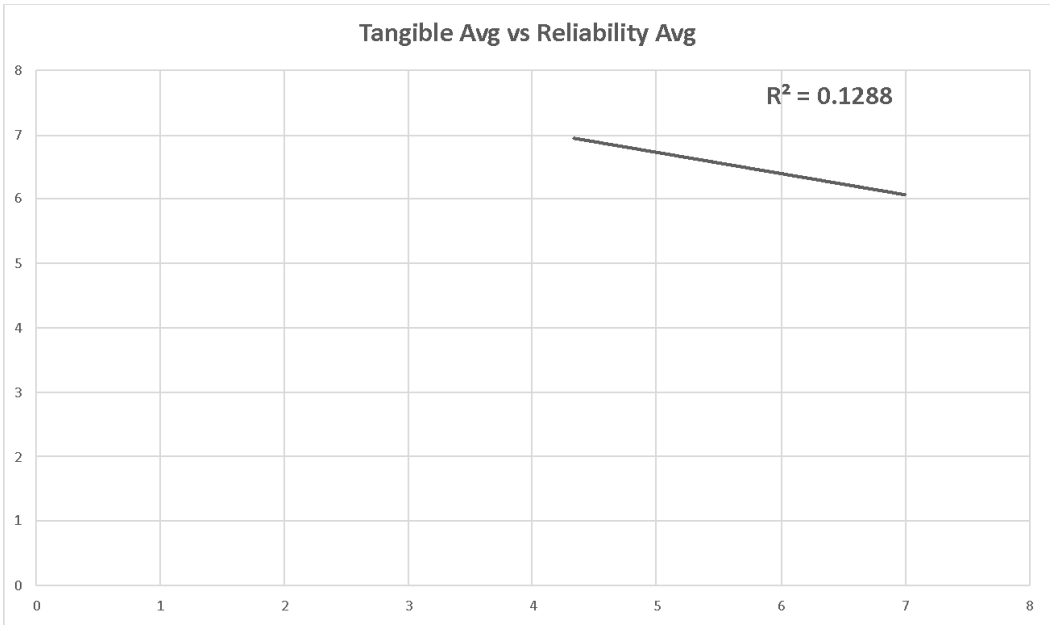

Figure 5.11: Shows, QoS Expectation variables, Tangible vs Reliability subjected to the Regression analysis

In the Scatter Plot Figure 5.11, the relationship and strength between two variables; Tangible average vs Reliability average is depicted, which shows $R^2 = 0.1288$

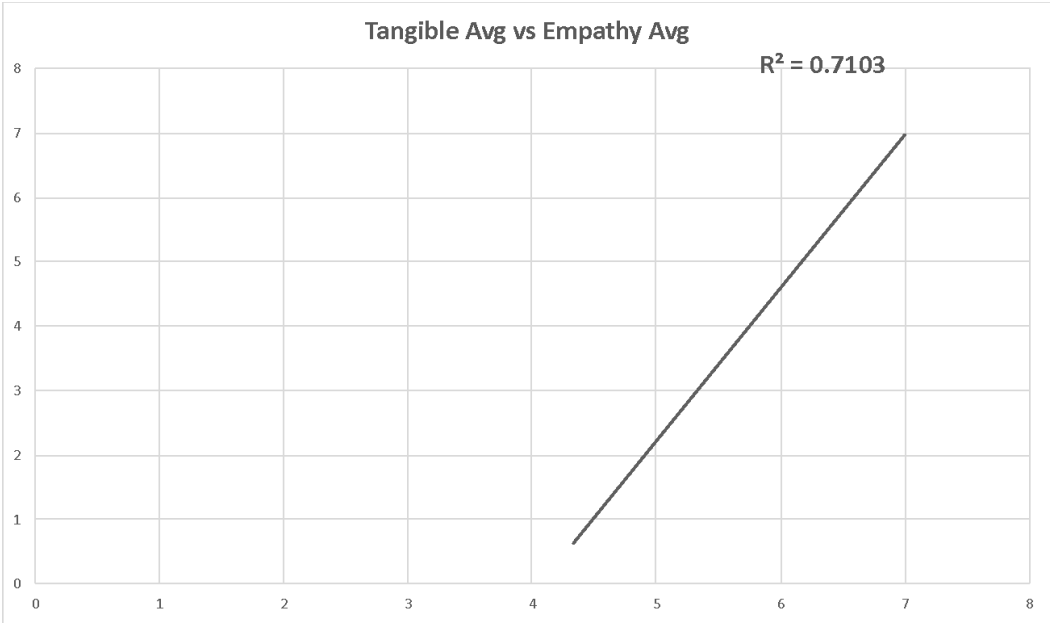

Figure 5.12: Shows QoS Expectation data for Variable Tangible vs Empathy subjected to the Regression analysis

In the Scatter plot in Figure 5.12, the relationship and strength between two variables; Tangible average vs Empathy average is depicted, which shows R^2 = 0.72204

The R square values (from regression graphs show) R^2 value in range from 0.00474 to 0.72204- which indicates variation from weak to strong association between the variables in the QoS expectation for academic CC users.

The graphs and values of R square of linear regression analysis for variables of QoS expected and experienced for Indian Universities CC academic user in real time further quantifies our data and proves that the selected variables have **strong association between them and have the power to influence the outcome which is QoS of higher education in Cloud Computing.**

5.6 SELECTION OF STATISTICAL TEST "ANOVA"

Use of **one-tail ANOVA test** was included since the current study is interested in looking at the increase value of outcome to relate to if the QoS was satisfactory also known as Directive Test, and such test is equally as significant as two-sided tail. (reference: https://www.Onesided.org ").

5.6.1 ANOVA selection for data analysis and not T-test:

In the present study, even though the data collected in real time was observed to be normally distributed, -T-test was not chosen for analysis. The number of variables in T-test can be only 2 -while the current study has 5 QoS variables for which survey data was collected from 5 different Indian Universities. While T-test is providing reliable analysis when there are only 2 groups / variables to analyse. To clarify, in both types of T-test, simple sample T-test (uses mean of single sample to be compared to a known population mean) and in T-test for 2 dependent or independent variables uses means of two data inputs which are precisely related to each other. While ANOVA calculates difference in variance (shows as "Sum of Squares in Table), for within or between Indian Universities or with International Universities. Therefore, as per requirement of study the ANOVA statistical test was selected to pursue the data analysis.

5.7 RESULTS OF THE PILOT STUDY

A smaller dataset analysis was conducted and compared for QoS.

In-order to understand the selection of variables for QoS in the present study, two Pilot studies were conducted to understand the parameter for larger data survey for the research. ANOVA results for the pilot study are shown in the table below.

Table 5.2: ANOVA (one-way Analysis of variance) summary table for the results from PILOT STUDY

Variables	Mean	Standard Deviation	Median	Average Absolute deviation from Median
(i) Expectations of QoS				
- *on tangibles*	3.70	1.34	3.50	1.10
- *on Assurance*	4.30	1.89	4.50	1.50
- *on Responsiveness*	5.00	1.41	5.00	1.00
- *on Reliability*	3.70	2.11	3.00	1.00
- *on Empathy*	4.00	1.63	4.00	1.70
ii) **Experience of QoS**				
- *on tangibles*	3.60	1.78	3.50	1.40
- *on Assurance*	4.20	1.93	4.50	1.60
-*on Responsiveness*	3.80	1.93	3.50	1.60
- *on Reliability*	4.10	1.91	3.50	1.50
- *on Empathy*	5.40	1.84	6.0	1.40
Overall QoS Experienced	5.50	0.972	6.00	0.70

Analysis of variance

Source of Variation	**Sum of Squares**	**Degree of Freedom (d.f.)**	**Mean Squares**
Factor	31.56	9	3.507
Error	289.2	90	3.213
Total	320.8	99	
F:1.091			

The first pilot survey for real time QoS for academic CC users investigated survey data collected from with the Librarian of the Center. The librarian in-charge evaluated that there are two relevant reasons that are having a major impact for implementation of CC for their higher educational user library, though there was available data to infer about the QoS from the University population. Secondly, there was uncertainty about the use of CC and its integration in their technological system. Understanding of such challenging circumstances prevailing in real time can help improve the academic as well as higher educational achievement of that region.

The real time survey data for QoS was from the second pilot survey response. The personnel were aware of different CC service providers and options offered and supported the concept about having more educational benefits with CC implementation in that higher education Center. The Center at that Institution had even trained staff to support the CC set-up.

5.8 QoS SURVEY WITH 238 SAMPLES AND ANOVA: ONE-WAY ANOVA FOR QoS EXPECTATION AND EXPERIENCE DATA

The data for expectation of service quality for all the five selected variables in the present study was subjected to One way-ANOVA. Through Analysis of Variance or ANOVA the difference among the means of all the population can be investigated simultaneously. In the current study, variance in expectation data within the Indian university and between the Indian and international university groups is computed and compared. The tables given below provide the summary of the QoS expected and QoS experienced data and draws conclusions from it. The p-value is computed based on the value of F-ratio. If $p<.05$ then the null hypothesis is rejected otherwise accepted.

5.8.1 Results for One- way ANOVA for QoS Expected

ANOVA was computed on data of QoS expected and the summary and results are shown in the tables below.

Table 5.3 Summary of ANOVA ANALYSIS on QoS Expectation Data

	Variables					
	Tangibles	**Assurance**	**Responsiveness**	**Reliability**	**Empathy**	**Total**
N	238	238	238	238	238	1190
ΣX	1277.2	1487.79	1190.09	1573.8	737.8	6266.68
Mean	5.3664	6.2512	5.0004	6.6126	3.1	5.266
ΣX2	6916.7368	9323.2725	6017.0035	10458.76	2789.56	35505.3328
Std. Dev.	0.5147	0.31	0.5281	0.4677	1.4559	1.4513

Analysis of Variance

Source	**SS**	**Df**	**MS**	
Between Variables	1798.373	4	449.5932	F = 868.82401
Within Variables	705.8857	1185	0.5957	
Error	490.5647	948	0.5175	

The F-ratio value is 868.82401. The p-value is < .00001. The result is significant at $p < .05$.

There is a significant difference in the expectation of users of cloud computing applications and services within and between the Indian universities. Since the p-value based on the F-ratio is <.05 the result is significant for difference observed for the value of variables in this study.

5.8.2 One- way ANOVA for QoS Experienced

ANOVA was computed on data of QoS experienced and the summary and results are shown in the tables below.

Table 5.4 Summary of ANOVA ANALYSIS on QoS Experienced Data

	Variables					
	Tangibles	**Assurance**	**Responsiveness**	**Reliability**	**Empathy**	**Total**
N	238	238	238	238	238	1190
ΣX	824.01	625.71	542.45	616.4	584.6	3193.17
Mean	3.4622	2.629	2.2792	2.5899	2.4563	2.683
ΣX2	3140.6301	2150.1459	1741.9369	2047.36	1996.04	11076.1129
Std.Dev.	1.1018	1.4599	1.4606	1.3794	1.5373	1.4523

Analysis of variance

Source	**SS**	**Df**	**MS**	
Between Variables	198.3054	4	49.5763	F = 892.58416
Within Variables	2309.4591	1185	1.9489	
Error	52.6543	948	0.0555	

The F-ratio value is 892.58416. The p-value is < .00001. The result is significant at $p < .05$.

There is a significant difference in the experience of users of cloud computing applications and services within and between the Indian universities. Since the p-value based on the F-ratio is <.05 the result is significant.

Conclusion

The above Analysis of Variance (ANOVA) of expectation and experienced data for CC QoS, draws conclusion that as the p-value is .00001 which is less than .05, the result is significant means there is a difference in the means of groups and therefore the null hypothesis for all the five variables can be rejected and the alternate hypothesis for all the five variables can be accepted.

Decision Rule and Goodness of Fit

One-way ANOVA was conducted that gave the "goodness of fit for the variables selected as per above criteria. From the results of ANOVA, it can be inferred that the selection of variables was fit for the current study which further helps in predicting the gap logistic model for QoS of cloud computing applications and services in the higher education sector.

5.9 RESEARCH QUESTIONS

Two research questions were examined in the current study. The questions were answered using the quantitative statistical tools and methods, starting with the first one below:

(1) Does any difference exist between the CC expected QoS and the QoS experienced by them while using the cloud computing applications and services? (Focussing on the state-run Academic Universities in India)

The above research question was answered by quantification of the variables and the data collected. Descriptive analysis, Levene's test of homogeneity of variance,

linear regression and inferential conclusion by ANOVA were used to show that there is a difference between the real time QoS as expected by the academic user and received by the user while using the CC.

5.9.1 Comparison of Indian Universities with International Universities for QoS

To better understand the differences in the QoS, USA University taken as reference for comparison of QoS to Indian QoS Values.

Table 5.5: ANOVA Results of Survey data conducted in 2018 for the variables (the number N=5) from College level students from Indian and USA Universities. The variables were subjected to statistical analysis at 95% Confidence level, with df = 1, to find which is significant (when p<.05) that would help build the QoS model for use of CC in higher education recommendation (df= degree of freedom)

Variables	**Mean**		**Standard Deviation**		**SS (Sum of Squares bet. two Univ users)**	**F**	**P**	**Result Not Significant Or significant At p< .05**
(i) Expectations of QoS	Indian Univ User	USA Univ User	Indian Univ User	USA Univ User				
- *tangibles*	5.66	6.0	1.60	2.44	2.08	0.49	0.48638	Not significant
- *Assurance*	6.33	6.89	0.52	0.41	0.75	3.46	0.924	Not significant
- *Responsiveness*	4.83	6.83	1.72	0.41	12.0	7.66	0.0198	Significant
- *Reliability*	6.33	6.6	0.82	0.52	0.33	0.714	0.417	Not significant
- *Empathy*	2.4	6.2	1.14	0.84	36.1	36.1	0.00032	Significant
ii) **Experience of QoS**								
- *tangibles*	3	5.5	0.63	1.05	18.75	25	0.000537	Significant
- *Assurance*	2	6.33	1.27	0.52	56.33	60.35	0.000015	Significant
- *Responsiveness*	1.66	6.83	0.512	0.41	80.08	369.6	0.00001	Significant
- *Reliability*	2	6.4	0.707	0.54	48.4	121	0.00001	Significant
- *Empathy*	1.8	6.8	0.44	0.45	62.5	312.5	0.00001	Significant

The above tabular analysis of Expectation in QoS responsiveness and empathy showed significant difference between the higher studies students of Indian and USA universities, meaning there was a difference between their cloud computing service quality. This can be attributed to the difference in resources available like funding, infrastructure, management decision making criteria which are currently required to be adopted here at Indian academic sector to solve QoS service problems. Indian administration of higher education who is still preparing the resources to be as the same standard as the international level, can be advised based on the model derived in this study to consider the selective criteria for strong attention to achieve higher success in CC services.

To obtain stabilized results in comparative groups under study for QoS Analysis, following valid assumptions with constraints were depicted as to be used with ANOVA:

1. All the data population was normally distributed.
2. Variances of the population as equal.
3. Made independent observations: The surveys for QoS collected from academic population was taken independent of each other and were randomly collected from their population.
4. The null hypotheses, as we conducted ANOVA, was that the population means for QoS in experience and expected was equal while the research (Alternative) hypothesis was that at least one of the population means was not equal.
5. The model was correctly specified to plug in the results from the ANOVA.
6. Also, in results that data would have a cut-off value of F-Statistics (where F is the ration of two mean squares) from ANOVA analysis as F<equal or less than 3.5 for non-significant results, and any data set with higher F values were depicted as significant.

However, the significant value in results at national level, CC end user population of higher studies for the experience of QoS indicated that it needs extensive re-modelling to match the satisfaction of service quality as compared to academic users at international levels in the same sector.

5.9.2 Dimensions of QoS assessment with Service Quality GAP model

To understand the difference in QoS in CC for Indian and SUNY, USA, the students was calculated. The results were further used to build the prototype "GAP MODEL", for the end users of CC who were registered into various scientific studies and are depicted in the following figure.

The table 5.6, shows that the International educational centre (USA) had met satisfactory SERVQUAL score value in most of the expectations to experience comparative differences and was even excellent in almost all levels, in the studied dimensions**.**

Table 5.6: Comparative Analysis showing mean difference in QoS related to between "Expected Score" and "Perceived Score" in QoS for academic end users of Cloud services at Indian and USA (International) Institutions in real time case studies

Dependent Variables for Quality of Cloud Services	Mean of Expectation Score $(ES)_i$ (Indian Uni.)	Mean of Perceived Score $(PS)_i$ (Indian Uni.)	Mean of Expectation Score $(ES)_u$ (USA Uni.)	Mean of Perceived Score $(PS)_u$ (USA Uni.)	Mean Difference in Service Quality $(ES)_I - (PS)_i$	Mean Difference in Service Quality $(ES)u - (PS)u$
Tangibles	5.66	3.0	6.00	5.5	2.66 ***ES > PS***	0.5 ***ES ~PS***
Assurance	6.33	2.0	6.89	6.33	4.33 ***ES > PS***	0.56 ***ES ~PS***
Responsiveness	4.83	1.66	6.83	6.83	3.17 ***ES > PS***	0.0 ***ES <PS****
Reliability	6.33	2.0	6.60	6.40	4.33 ***ES > PS***	0.2 ***ES ~PS***
Empathy	2.40	1.8	6.20	6.8	0.6 ***ES <PS***	-0.6 ***ES <PS****

However, to co-relate directly in positive value, calculation was done by using (ES-PS) in the above table. The above table 5.6, shows ***overall average weighted SERVQUAL*** in both Indian and SUNY University, USA. The value's reported imply their significance to infer about the QoS in CC to analyse findings, since all expectation levels of Cloud computing services that were being experienced by the current students and staff were recorded in real time for this cross-sectional study.

To follow the common approach to infer for the observed values, where experience or perceived SERVQUAL score is subtracted from expected value **(PS-ES)**, the range of negative value would be the difference in level of offered services by CC used by students / staff as compared to their expectation.

5.9.3 Second research question addressed

Two research questions were examined in the current study. The questions were answered using the quantitative statistical tools and methods. The second question was:

(2) Is there any difference between the QoS expected and experienced by the Indian and the international users of the higher education sector, in Government / State run colleges and universities?

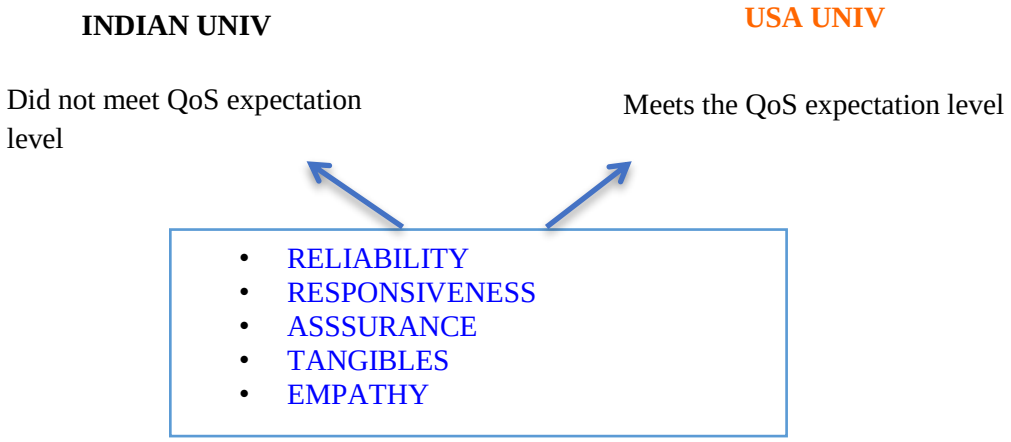

Figure 5.13: Shows (ES) and (PS) values comparison between Indian and US Universities

Neither of the dimensions meet the expectation level of Cloud computing services being experienced by the current students and staff as recorded in real time data collection in this study. From the above analysis of data for Indian and International students, we can infer that there is a difference between the QoS of cloud computing being provided to the higher education students of India is significantly different (experience was less than the expectation) from the cloud service quality provided to the SUNY students.

5.10 DEMOGRAPHIC DATA

The number for overall demographic distribution was taken into consideration for evaluating the influence of geographic location and effect of region-specific governance that has an effect to make decisions about CC implementation at the higher educational institutions.

Table 5.7: Demographic data for CC quality service survey at higher education Institutions

Institution (Name and Location)	**# of Students Gender** **M F**	**Age (yrs.) (range)**	**Academic Status per Centre** **Students** **Faculties**
JaganNath Institute of Management and Sciences (JIMS, Engineering & Technical Campus, Greater Noida, India. (50)	35 15	22-30	Graduate (28) Prof (2)
Dr. B.R. Ambedkar Central Library, Jawaharlal Nehru University, New Delhi, India. (56)	30 26	20-40	Graduate (53) Librarian (3)
Banaras Hindu University, Varanasi, UP, India (64)	45 19	19-35	Graduate (59) Prof (5)
VES College of Pharmacy, Chembur, Mumbai, India. (68)	40 28	18-30	Graduate (67) Prof (1)
State University of New York (SUNY), Albany, NY, USA. (41)	**22 19**	**18-45**	**Graduate (39) Prof (2)**

Total Indian University survey participants = 238

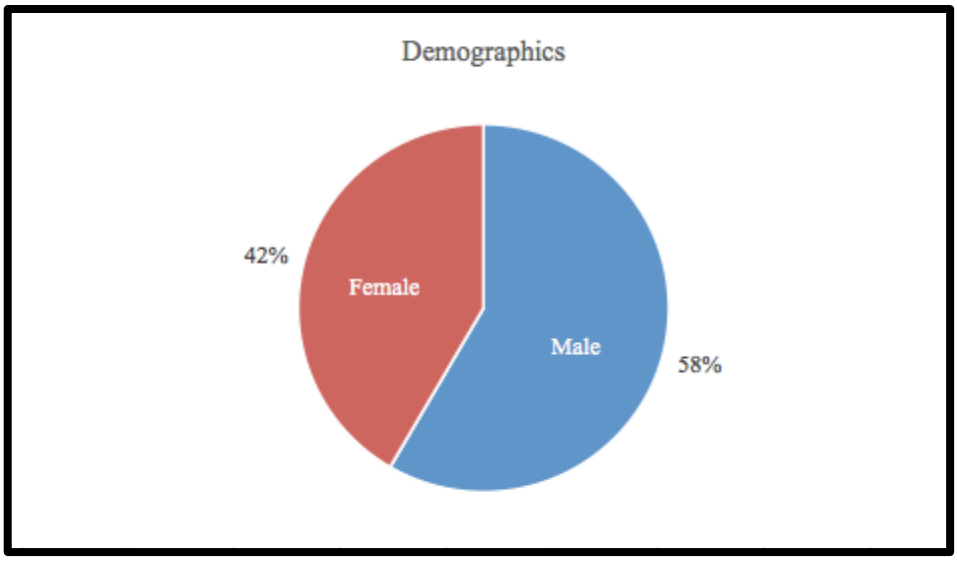

Figure 5.14: Shown the percentage distribution of male and female Indian students who contributed in the current survey

The above figure 5.14 shows that in the current survey study the number of male participants more than female users.

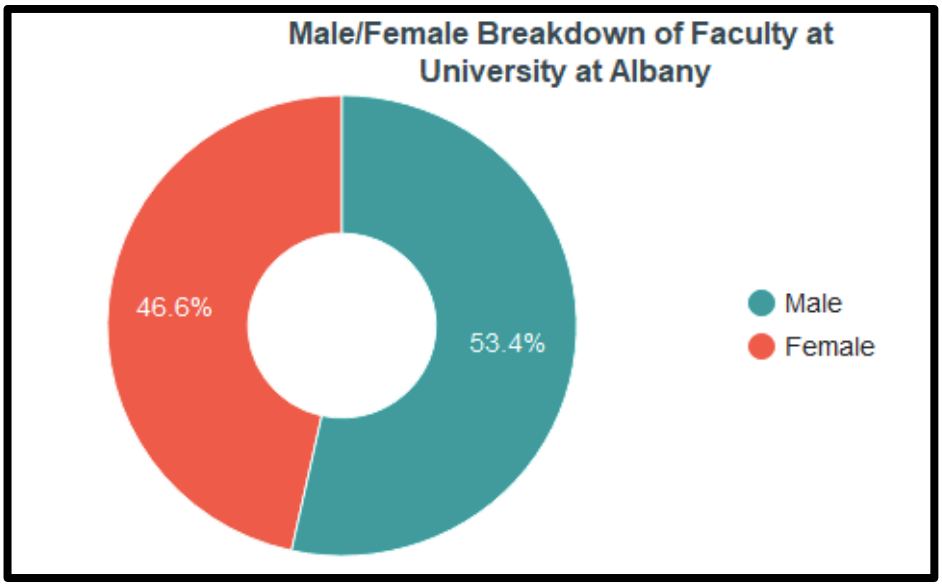

Figure 5.15: Shown the percentage distribution of male and female SUNY, NY, USA students included in current QoS survey

Similar results for US university as a greater number of male's users participated but current study did not design any survey questions to address this issue, which also is out of the scope of present study.

Reason for choosing SUNY or comparative analysis (Govt)

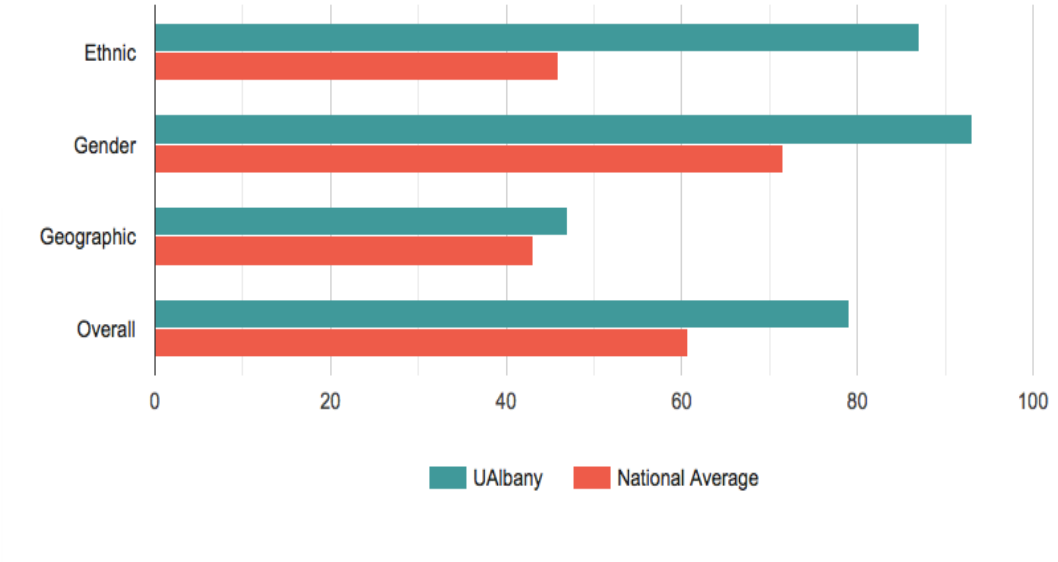

Figure 5.16 shows Demographic statistics of American University

Shown here is SUNY (the bluish green bar), gender, ethnicity geographic variation in academic members is compared with USA National values (in red), and SUNY exceeds its National values (has more gender variation.)

The survey did not have any questions formatted in a survey instrument that could help analyse the difference in male: female ratio. It was observed that during the analysis of the data that the number of users of male academic respondents was more than female academic responders. But it was considered an independent variable as it does not affect the QoS expected and experienced by the users of cloud computing applications and services for higher education.

5.11 CONCLUSION

This chapter summarizes the statistical methods and tools used for descriptive analysis of data and discuss in detail the implementation of statistical methods for drawing inferential conclusion of rejecting the null and accepting alternate hypothesis for the present study. It also presents goodness of fit and decision rule for a predictive logistic GAP model for QoS in cloud computing applications and services in higher education sector which shows the details about the gaps in cloud computing service quality expectations of the users and the actual service quality being experienced by the users.

CHAPTER 6: CONCLUSION, DELIVERABLES, LIMITATIONS, RECOMMENDATIONS AND SUMMARY

6.1 INTRODUCTION

The objective of the present real time data survey from academic users, was to measure the QoS expected and experienced by the users of the higher education sector and to deduce if there is any difference between the two. In addition, to provide a benchmark for quality of CC services being provided, it also compared the QoS of cloud applications and services as expected and experienced by the Indian users' and the International (USA) users'.

6.2 RESEARCH FINDINGS

The two primary research questions analysed in the current study were:

(1) Does any difference exist between the QoS expected by the users' and the QoS actually experienced by them while using the cloud computing applications and services? (Focussing on the state-run colleges and universities in India), and,

(2) Is there any difference between the QoS expected and experienced by the Indian and the international users of the higher education sector, in state-run colleges and universities?

For answering research question one, null and alternate hypothesis were framed for each of the variables selected for measuring the QoS through the survey instrument designed for the current study. It was found that for all the five variables assurance, tangibles, reliability, empathy and responsiveness, there was a difference between the expectations of the users' and experience of the service by the user. All these differences lead to low value of overall QoS experienced by the academic user.

The result after determining the estimate for each variable showed a significant result as the value of p was less than .00001 and the results are considered significant if the value of p is less than .05. This led to the rejection of the Null hypothesis in favour of the Alternate hypothesis.

The demographic data did not affect the scores of expectations of QoS expected by the users of higher education and the QoS experienced by them. As in the current study, the users were mainly students and faculty of higher education institutes and they can be of any age or income group therefore having no effect on their expectation or experience for QoS of CC applications and services.

6.3 HYPOTHESIS TESTING RESULTS AND ITS ANALYSIS

The following table shows hypotheses were either rejected or accepted on the ANOVA results. The real time data collected of end users of CC at higher education in Indian as well as USA Institutions will be now subjected to statistical analysis using ANOVA. The difference between the QoS expected and experienced in CC indicates the higher (best) or lower(bad) service quality for college students and faculties. It is expressed in the table below:

Table 6.1: Showing the result analysed for the proposed hypothesis for this real time study for CC QoS, in the higher education sector. H_0 relates to null hypothesis and H_A to alternate hypothesis.

No		Hypothesis	Statistical Method	Rejected/ Accepted
H1	$H_0$1	*Empathy* level was same for QoS expected and QoS experienced by academic users of CC	ANOVA	Rejected
	H_A1	*Empathy* level was different for QoS expected and QoS experienced by academic users of CC	ANOVA	Accepted
H2	$H_0$2	*Responsiveness* level was same for QoS expected and QoS experienced by academic users of CC	ANOVA	Rejected
	H_A2	*Responsiveness* level was different for QoS expected and QoS experienced by academic users of CC	ANOVA	Accepted
H3	$H_0$3	*Assurance* level was same for QoS expected and QoS experienced by academic users of CC	ANOVA	Rejected
	H_A3	*Assurance* level was different for QoS expected and QoS experienced by academic users of CC	ANOVA	Accepted
H4	$H_0$4	*Reliability* level was same for QoS expected and QoS experienced by academic users of CC	ANOVA	Rejected
	H_A4	*Reliability* level was different for QoS expected and QoS experienced by academic users of CC	ANOVA	Accepted

H5	$H_0$5	*Tangibility* level was same for QoS expected and QoS experienced by academic users of CC	ANOVA	Rejected
	H_A5	*Tangibility* level was different for QoS expected and QoS experienced by academic users of CC	ANOVA	Accepted
H6	$H_0$6	QoS expected and QoS experienced by academic users was the same at the Indian and International level.	ANOVA	Rejected
	H_A6	QoS expected and QoS experienced by academic users was different at the Indian and International level.	ANOVA	Accepted

The above table shows that for answering research question 1, for H1 to H5 null hypothesis was rejected in favour of the alternate hypothesis. For answering research question 2, null hypothesis H6 was rejected in favour of the alternate hypothesis.

For reaching the above conclusion, first the descriptive analysis was done to check the viability of the data. After that, ANOVA was conducted to reach the inferential conclusion by ANOVA. Before conducting ANOVA, first the assumptions of ANOVA were met. First to assess the data for normality, the data was subjected to Levene's test. The results for some pairs of variables showed violation of assumptions but ANOVA can work with some violations as it is a robust statistical tool and can work with minor assumptions as the sample number or the current study is large. Next linear regression was conducted to assess the relation between the variables and the degree of strength between them. After meeting the assumptions, ANOVA was conducted which gave significant results as p-value was less than .05 for all the variables. Also, for the analysis done using ANOVA for service quality expected and experienced by Indian and international students, the result for expectation of tangibles, assurance and reliability were not significant

showing p-value greater than .05 while responsiveness and empathy showed significant result with p-value less than .05. But for all the five variables for experience data, ANOVA showed significant results with p-value less than .05, thus rejecting null hypothesis in favour of alternate hypothesis for H6.

6.4 DELIVERABLES

The current study resulted in the following deliverables:

1. The prediction of a service quality gap model for defining the difference between the QoS expected and experienced while using the cloud computing applications and services by the users of the higher education sector. All the gaps were addressed and the reasons for these gaps and the suggestions to close them are also discussed. The variables selected in the current study for measuring the QoS were also associated with the gaps so that it becomes easy to analyse them.

6.5 PREDICTIVE SERVICE QUALITY GAP MODEL

Service Quality can be defined as difference between service quality expectations and service quality experience along the quality dimensions (Parasuraman, 1985). Based on the statistical analysis of our data using descriptive computing and inferential conclusion using ANOVA, a Gap Logistic Regression Model is predicted for analysis of cloud computing services' quality as perceived by users as compared to QoS expected by the users of cloud computing in the higher education sector. The QoS Logistic linear regression model is used to address the expectation of students in higher education for improved Cloud computing experience. Gaps were addressed based on their origin and some suggestions to close the providers' gaps and customers' gaps were also highlighted.

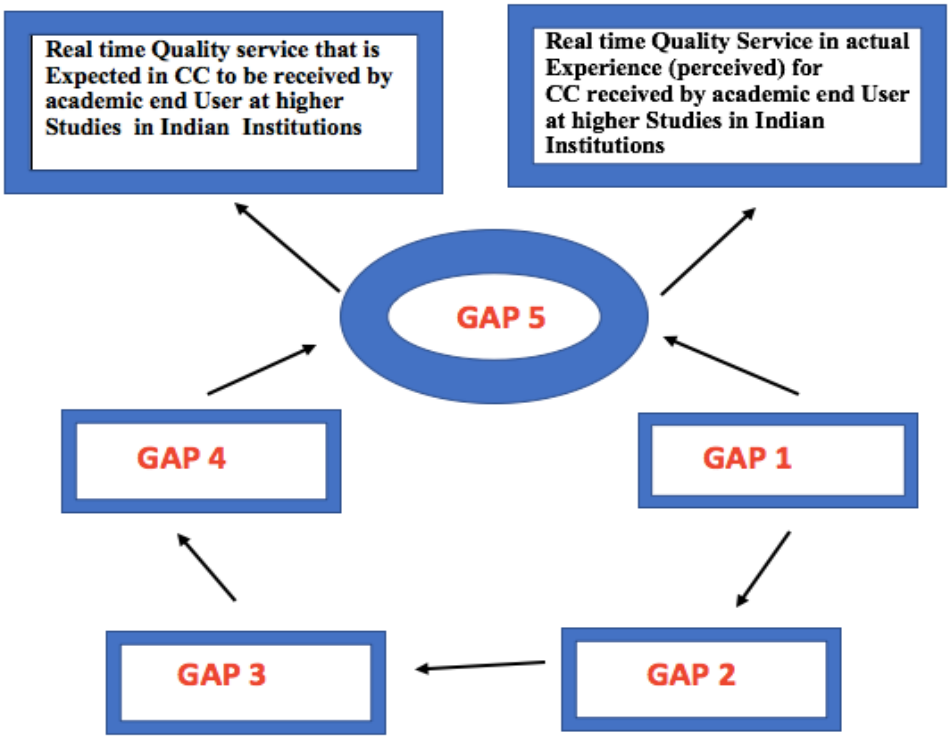

Figure 6.1: The Gap between higher education end users' expectation and experience (or perception) is shown as Gap 5 which is in fact caused by other 4 gaps, shown by connecting arrows. Calculated GAP = QoS expected minus QoS experienced.

Analysis of Gap 1-5 has been performed, with suggested interventions to bridge and close these gaps.

GAP 5 alias Customer Gap: There exists a difference between the CC service expectation and perceptions by the students/staff /library personnel, since expectations were not up to standards required to meet the course design set at the University / college. This is the outcome of contributions by gaps in 4 different links affecting this quality of CC service.

GAP 1 alias Provider Gap 1: The main cause for development of this gap was evaluated to be due to the lack of indirect resources to understand what are the essential needs of the students or educational staff and faculty when they start utilizing of CC service provided by the centre, who in turn is dependent on outside contractor for this service. It was seen from the survey that there is a lack of understanding to interact with students to obtain a semester course and need for related data or software essential to fulfil it.

GAP 2 alias Provider GAP 2: This gap has been identified to arise due to the lack in selection of right cloud computing service designs and standards that were being used by higher educational students and staff.

GAP 3 alias Provider GAP 3: This gap was contributed by fault of provider as they did not deliver CC services to required service standards as per higher educational end users demand in this study**.**

GAP 4 alias Provider GAP 4: This gap could be assigned here to the unmatched contractor promises to experienced performance in CC service as reported by the students and staff in this study.

6.6 FUTURE INTERVENTIONS

Framework for future as derived from the current real time CC QoS research Study can be outlined as follows:

(A) To close the GAPS of Quality service for CC end users at higher education sector:

1. **<u>To Close GAP 1</u>:** Efforts should be directed **to understand what the students and staff expect** at higher education sector, like essential package of CC service should include some basics to start with like required software's as per subjects offered in the curriculum, a high or optimum internet connection speed, problem solving support system, security

management as to address the concerns to protect students and staff identity thefts etc**.**

2. **To Close GAP 2:** Efforts should be directed to establish **correct service quality standards** by getting inputs from students and staff who are end users of Cloud Computing.
3. **To Close GAP3:** The higher education governance should direct resources to make a management committee to oversee that the **Cloud Computing service performance meets the required standards** for its end users.
4. **To Close GAP 4**: In order to remove this gap, efforts should be directed to confirm that **delivery of CC services has matched the promise** made by the provider or contractors for their business based on their achievement of demand satisfaction and good service quality of Cloud Computing.

(B) Relation of Cloud Computing services observed GAP in this study to higher education population

All the above discussed GAP criteria in future can be easily evaluated by the higher education governance / management from establishing an online survey every 2-3 month for the students and staff, which can be made attractive especially to the students by providing incentives like extra credits when they complete the survey regarding CC services as per their experience and expectations.

Shown in the figure below are the various gaps and its likely occurrence, also the variables identified for measuring the gaps in the current study are being related to the gaps.

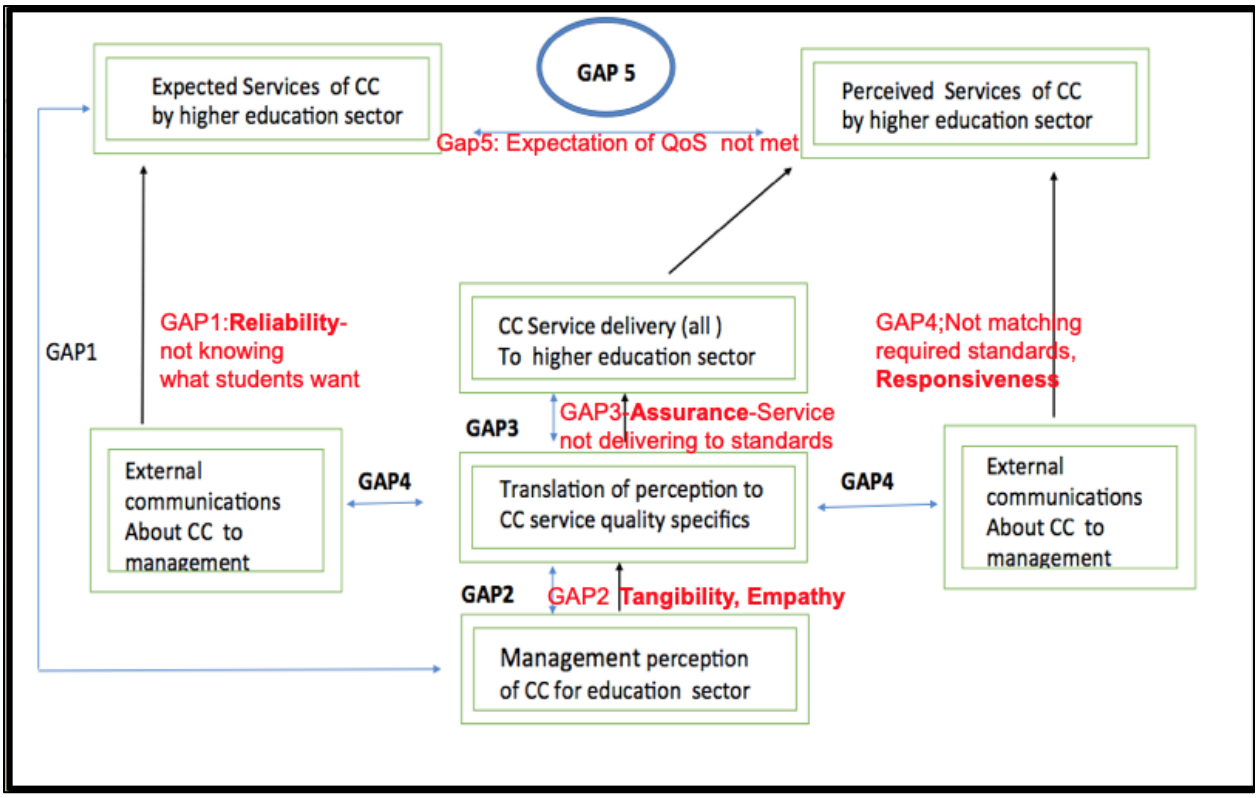

Figure 6.2: Prototype of QoS Logistic GAP Model for higher education sector, as derived from the current study based on Parasuraman et al., (1988)

Relation of the identified variables in the present study with the gaps in the QoS Logistic Gap model predicted and their likely occurrence.

There exists a relation between the gaps and the variables identified in the present work. It is summarised as below:

1. **Gap 1** is closely associated with one of the five variables reliability, which focuses on inability or lack in desire of the provider to know about the exact requirements and expectations of the user. This means that the users' find the services given by the provider as unreliable or less reliable. This results as a first step towards service quality related dissatisfaction of the user.

2. **Gap 2** is closely associated with two variables tangibility and empathy which put focus on the inability of the provider in selecting the right cloud computing services for the user which may arise as a result of gap1. This accounts to users' not being provided services with the required look and feel as per their requirement and also with the in-sensitivity of the provider to identify with the issues related to QoS. It focuses on the inability or disinterest of the provider in getting aware of and solving the users' requirements and issues related to the cloud computing services which they provide.
3. **Gap 3** is closely associated with variable assurance, which focuses on the fault of the provider in lack of delivering the cloud computing services as per the required service standards according to the user. This accounts to the users' dissatisfaction on the lack of assurance from the providers to deliver right services to them.
4. **Gap 4** is closely associated with the variable responsiveness, which focuses on the exaggeration by the provider regarding the services that will be provided to the users, thus raising their expectations but not responding with the services as promised and in the process harming users' perceptions of QoS.
5. **Gap 5** known as the big customers' gap is a result of all these four providers' gaps which are closely associated with the five variables tangibility, assurance, reliability, empathy and responsiveness.

We can thus conclude that the predictive logistic gap model has close association with the variables identified and applied in designing the survey instrument to gather data in the current study which makes this model suitable and appropriate in defining the difference in QoS experienced and QoS experienced by the CC users of the higher education sector.

6.7 SUMMARY

We can summarise the deliverables as following:

1. Use of QoS Logistic regression model to address the expectation of students in higher education for improved Cloud computing experience
2. A Gap Logistic Regression Model predicted for analysis of cloud computing services' quality as perceived by users as compared to QoS expected by the users of cloud computing in the higher education sector.
3. Research that measures user satisfaction of cloud computing applications.
4. Suggestive Approach to improve: Based on (ES – PS) values, specific CC dimensions could be addressed by using follow up survey as a tool.

An update: Currently a similar survey instrument to evaluate the quality of CC for different educational sections by implementation of Virtual labs has been launched in UPES, in April 2019.

6.8 CONCLUSION

The conclusions reached from the analysis of the current study are summarised below:

1. The developed instrument, can be implemented to help academic organization to improve and build up the existing gaps in CC by taking inputs from the proposed Model / equation that has been obtained for CC related QoS at educational Centres. Based on the GAP score value, specific dimensions could be addressed and then a follow up by survey can be used as a tool to evaluate the effectiveness of changes implemented.

Few factors were mainly considered for delaying the implementing CC:

- Not being sure about the QoS provided
- Uncertain about the incorporation of CC technology with the existing QoS model.
- Experience of QoS is not an acceptable level when compared to Expected (ES> PS), within Indian students and faculty and with international students and faculty.

2. Comparison of two user populations pursuing higher studies for the experience of QoS indicates that it needs extensive remodelling. Need and demand value: an overview of all students enrolled in college of higher studies, would be highly improved with interventions as suggested by this study, aiming at overall student population and hence National educational benefit.
3. Existence of a huge gap in all five dimensions, directly influencing the QoS of Cloud computing offered at Indian higher educational Centres when compared within and with an International educational Center.

6.9 LIMITATIONS OF REAL TIME QoS STUDY

Although there were significant results and deliverables of the current study, it is important to mention some limitations of this study. In this section, these limitations are mentioned that can be addressed in the future research scenario.

1. The most difficult part of the study was data collection. The majority of the students, or the academics were hesitant to provide a survey since they felt it could break the University administration guidelines.
2. Survey was lengthy as there were a total 28 questions in each expectation and experienced QoS and one question for overall satisfaction of the user, also 6 questions for answering the demographics. So, the total number of questions to be answered was 63 which were considered lengthy by the students.
3. Most colleges did not entertain the email survey and with the inability to travel to all locations to do the same, resulted in difficulty in gathering the data.
4. GAP Model Limitation: No information or involvement of students or staff was reported to exist as to influence over the academic decision making for funding and selection of the cloud computing services provider directly.

6.10 FUTURE RESEARCH SUGGESTIONS

The current work measures the expectations and experience of the QoS of CC technological services provided to the users of higher education. Additionally, it also investigates if there is any gap between the QoS that is expected and experienced by the CC users of higher education in India and at international level. Some research suggestions which are open for future research are mentioned below:

- Identification and classification of QoS metric for higher level education sector at varied geographic locations in India and at international level. Study can be conducted at other places around the globe to investigate the QoS technology of CC applications and services.
- Qualitative survey analysis of QoS based on varied educational divisions, like engineering, or research or Medical sector, since each has its own data requirement for Cloud computing services**.**

6.11 SIGNIFICANCE OF PRESENT REAL TIME STUDY

This present study was mainly focused on the bachelor's or master's degree students in Sciences who were **real time users** of academic cloud computing services. Result analysis for this data from Indian education institutions in comparison to International educational institutions concluded that accepting an alternate hypothesis was directly related to the validation of QoS GAP regression model highlighting the existence of gaps in all five QoS dimensions, thus directly influencing the service quality of Cloud computing that is currently offered at higher educational centres in India. Understanding existing QoS GAP therefore would benefit immediately towards the improvement of QoS performance in Cloud Computing used by current Indian students in public and Government College at high educational centres. However, it will also require inputs or initiatives designed by the decision-making management of higher educational institutions, based on the recommendations of this study.

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APPENDIX A: SURVEY INSTRUMENT

Dear Cloud Computing user in higher education sector: you are invited to complete and return this 10-minute survey as a user of cloud computing services in higher education sector (users of library content, online journals, e-mail, online instruction software, online conferences or other IT services delivered via internet.).

The survey is divided into two parts, A, & B:

In Part-A the extent of the quality of service "expected" by the user for the different services rendered by the provider is measured and in Part-B the quality of these services actually "experienced" by the user of higher education sector.

Part A: Expectations of Quality of Service

Directions: The following **FIVE** sections relate to your expectations of the services you expect from an excellent cloud computing service provider in higher education for the services rendered. For each statement, please show the extent of your agreement with each feature described. Choosing '1' means you strongly disagree with the statement while choosing '7' means you strongly agree with the statement. The middle numbers give the average.

Section 1: Quality of service expectation on tangibles

Rate the visual impression of the provider's communication materials.

1.	The content and the organization of online content is easy to follow.	**7 6 5 4 3 2 1**
2.	It is easy to complete a session without any technical hindrance	**7 6 5 4 3 2 1**
3.	Using the provider's web site requires a lot of effort.	**7 6 5 4 3 2 1**
4.	A range of services are provided by the provider.	**7 6 5 4 3 2 1**
5.	Most of the services required are provided.	**7 6 5 4 3 2 1**
6.	All the services are included in the menu options.	**7 6 5 4 3 2 1**

Section 2: Quality of Service Expectation on Assurance

Please rate the expectations based on the ability of the provider to convey trust and confidence.

1.	Support staff can clear all the doubts.	**7 6 5 4 3 2 1**
2.	The provider will not misuse user's personal information.	**7 6 5 4 3 2 1**
3.	The provider complies with users' requests.	**7 6 5 4 3 2 1**
4.	User feels safe in online communications.	**7 6 5 4 3 2 1**
5.	Feels the risk related to online transaction is low.	**7 6 5 4 3 2 1**

6.	Feels the risk related to online communication is low.	**7 6 5 4 3 2 1**

Section 3: Quality of Service Expectation on Responsiveness

Please rate the expectations based on the willingness of the provider to help users and provide quick response.

1.	Support staff is able to give quick response.	**7 6 5 4 3 2 1**
2.	Response by e-mail or other means is useful.	**7 6 5 4 3 2 1**
3.	Support staff is never too busy to help.	**7 6 5 4 3 2 1**
4.	Problems are resolved quickly and effectively.	**7 6 5 4 3 2 1**
5.	Any requests are properly and timely handled.	**7 6 5 4 3 2 1**
6.	Any email query is timely handled.	**7 6 5 4 3 2 1**

Section 4: Quality of Service Expectation on Reliability

Please rate the expectations based on the ability of the provider to provide users with accurate information and perform the promised services accurately.

1.	Excellent services are provided in the specified time.	**7 6 5 4 3 2 1**
2.	Provider's promise to do something are kept.	**7 6 5 4 3 2 1**
3.	The users' records are kept accurately confidential.	**7 6 5 4 3 2 1**
4.	Error free records are maintained with the provider.	**7 6 5 4 3 2 1**
5.	Security and identity is to user satisfaction.	**7 6 5 4 3 2 1**

Section 5: Quality of Service Expectation on Empathy

Please rate the expectations based on the ability of the provider to provide users with caring and individualized attention.

1.	Individualized attention is given to the user.	**7 6 5 4 3 2 1**
2.	Support team gives personal attention to the users.	**7 6 5 4 3 2 1**
3.	The provider understands specific requirement of the user.	**7 6 5 4 3 2 1**
4.	The provider keeps users interest at the top.	**7 6 5 4 3 2 1**
5.	The provider operates at hours convenient to the user.	**7 6 5 4 3 2 1**

Part B: Experience of Quality of Service

Directions: The following **SIX** sections relate to your experience of the services you expect from an excellent cloud computing service provider in higher education for the services rendered.
For each statement, please show the extent o your agreement with each feature described. **Choosing '1' means you strongly disagree with the statement while choosing '7' means you strongly agree with the statement. The middle numbers give the average.**

Section 1: Quality of Service Experience on Tangibles

Rate the visual impression of the provider's communication materials

1.	The content and the organization of online content is easy to follow.	**7 6 5 4 3 2 1**
2.	It is easy to complete a session without any technical hindrance.	**7 6 5 4 3 2 1**
3.	Using the provider's web site requires a lot of effort.	**7 6 5 4 3 2 1**
4.	A range of services are provided by the provider.	**7 6 5 4 3 2 1**
5.	Most of the services required are provided.	**7 6 5 4 3 2 1**
6.	All the services are included in the menu options.	**7 6 5 4 3 2 1**

Section 2: Quality of Service *Experience* on Assurance

Please rate the expectations based on the ability of the provider to convey trust and confidence.

1.	Support staff can clear all the doubts.	**7 6 5 4 3 2 1**
2.	The provider will not misuse user's personal information.	**7 6 5 4 3 2 1**
3.	The provider complies with users' requests.	**7 6 5 4 3 2 1**
4.	User feels safe in online communications.	**7 6 5 4 3 2 1**
5.	Feels the risk related to online transaction is low.	**7 6 5 4 3 2 1**
6.	Feels the risk related to online communication is low.	**7 6 5 4 3 2 1**

Section 3: Quality of Service *Experience* on Responsiveness

Please rate the experience based on the willingness of the provider to help users and provide quick response.

1.	Support staff can give quick response.	**7 6 5 4 3 2 1**
2.	Response by e-mail or other means is useful.	**7 6 5 4 3 2 1**
3.	Support staff is never too busy to help.	**7 6 5 4 3 2 1**
4.	Problems are resolved quickly and effectively.	**7 6 5 4 3 2 1**
5.	Any requests are properly and timely handled.	**7 6 5 4 3 2 1**
6.	Software update problem is timely handled.	**7 6 5 4 3 2 1**

Section 4: Quality of Service *Experience* on Reliability

Please rate the experience based on the ability of the provider to provide users with accurate information and perform the promised services accurately.

1.	Excellent services are provided in the specified time.	**7 6 5 4 3 2 1**
2.	Provider's promises to do something are kept.	**7 6 5 4 3 2 1**
3.	The user's records are kept accurately confidential.	**7 6 5 4 3 2 1**
4.	Error free records are maintained with the provider.	**7 6 5 4 3 2 1**
5.	Account IDs are maintained timely.	**7 6 5 4 3 2 1**

Section 5: Quality of Service *Experience* on Empathy

Please rate the experience based on the ability of the provider to provide users with caring and individualized attention.

1.	Individualized attention is given to the user.	**7**	**6**	**5**	**4**	**3**	**2**	**1**
2.	Support team gives personal attention to the users.	**7**	**6**	**5**	**4**	**3**	**2**	**1**
3.	The provider understands specific requirement of the user.	**7**	**6**	**5**	**4**	**3**	**2**	**1**
4.	The provider keeps users interest at the top.	**7**	**6**	**5**	**4**	**3**	**2**	**1**
5.	The provider operates at hours convenient to the user.	**7**	**6**	**5**	**4**	**3**	**2**	**1**

Section 6: Overall Quality of Service *Experience*

Please rate how much the overall quality of service provided meets your expectations.

		Excellent						**Poor**
1.	How do you rate overall quality of services provided?	**7**	**6**	**5**	**4**	**3**	**2**	**1**

Part C: Demographic Information of the user

Please answer the following questions.

1. Name of the Academic Institution _____
2. Gender of the user _____
3. Age of the user _____
4. Yearly income of the user _____
5. Highest qualification of the user _____
6. Occupation of the user _____

APPENDIX B: LIST OF PUBLICATIONS

1. Upadhyaya, J., Ahuja, N. J. & Sharma, K.D. (2019). Evaluating User Expectations and Quality of Service: A Novel Approach to Understanding Cloud Services. *International Journal of Recent Technology and Engineering (IJRTE),*7(5S2). [SCOPUS Indexed].

2. Upadhyaya, J., Ahuja, N. J. & Sharma, K.D. (2019). Cloud Computing in Libraries and Higher Education: An Innovative User-Centric Quality of Service Model. *International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075*,8(6C). [SCOPUS Indexed].

3. Upadhyaya, J. & Ahuja, N. J. (2017). Quality of Service in Cloud Computing in Higher Education: A Critical Survey and Innovative Model. *IEEE Conference ISMAC2017* *http://ieeexplore.ieee.org/document/8058324/*. [SCOPUS Indexed].

4. Upadhyaya, J. (2013). Providing Effective e-governance with Green Computing; *International Journal of Research Review in Engineering Science and Technology.*

5. Upadhyaya, J. (2010). Analysis of Cloud Computing. *National Conference, Amity University.*

APPENDIX C: DATA COLLECTED AND ANALYZED

Data collected and analysed is available with the Guide and Scholar, and can be produced on demand.

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ORIGINALITY REPORT

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SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Jolly Upadhyaya, Neelu Jyothi Ahuja. "RETRACTED ARTICLE: Cloud Computing in Libraries and Higher Education: An Innovative User-Centric Quality of Service Model", The Serials Librarian, 2019 Publication	1%
2	Jolly Upadhyaya, Neelu Jyoti Ahuja. "Quality of service in cloud computing in higher education: A critical survey and innovative model", 2017 International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), 2017 Publication	1%
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