An Educational Virtualization Infrastructure

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Abstract. Virtualization is a key cost-cutting technology developed from the concept of cloud computing which provides efficient IT Solutions in corporate and educational sectors. We present an original structural framework for which the effects & implications of virtualization technology are measured based on a real campus wide deployment. The Virtual Desktop Infrastructure (VDI) provides academic members access to virtual applications and personalized virtual desktops on and off-campus for easy convenient access to academic resources. This paper provides intricate analysis on the perceived and categorical perspectives on the usefulness, effectiveness and values of this technology in an academic environment. Among other significant results, our results indicated that students and academic staff had positive experiences using virtualization technologies and have generally improved accessibility to their course documents and academic materials which enabled them to perform course work more effectively.

Keywords: VDI · I.T · Virtualization technology · Academia · Virtual lab application · Cloud computing

1 Introduction

Information Technology is with no doubt a key part of any educational infrastructure. Since educational institutions often lack the IT resources, virtualization and cloud computing technologies are often utilized in the teaching-learning process [1] where academic professionals can access the needed academic resources using virtual classrooms. Universities have utilized the benefits of virtual technologies in a number of university level subjects [2]. Cloud computing affects the way technological services are invented, and utilized The potential of cloud computing affects the functionality of existing information technology services and enables new functionalities that are thus far infeasible as it has massive effects on the cost of deployment and development of new IT services and tools which were preventing a number of key decision makers. Cloud computing exemplifies two major IT developments: IT efficiency and Business Agility. IT efficiency is exponentially increased by using advanced hardware and software tools and resources. On the other hand, Business agility also advances by using real time rapid deployment and parallel processing offering a competitive advantage to any company. In a related context, virtualization which can be considered as a subsidiary of cloud computing is defined as a set of software tools which divides a server into virtual resources called Virtual Machines (VM's) reducing power and expanding computing

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resource allocation and data storage [3]. Virtualization is one of the key areas being widely explored by many academic institutions given its high potential in offering computing resources to a large number of students with minimum cost of deployment and maintenance.

In this research work, we provide intricate analysis on the perceived and categorical perspectives on the usefulness, effectiveness and value of virtualization technology in an academic environment. Our analysis is based on extensive qualitative and quantitative data resulting from the deployment and implementation of virtualization technologies at a university. The platform of virtualization desktop infrastructure was provided by Citrix technology, one of the pioneers of virtualization technology amongst others such as Microsoft and VMWare. This research paper is outlined as follows. Section 2 states the research problem and its corresponding research questions highlighting the significance of this research work. Section 3 summarizes the related research work. Section 4 summarizes our research design and methodology and results. Section 5 concludes this work.

2 Problem Statement

Cloud computing is an emerging topic in the IT industry. Presently, universities have been considering the adoption of virtualization technology which is an application under cloud computing for various reasons. Adopting virtualization in a campus wide location is a very costly venture and when compared to the traditional method of installation and management of applications, it raises some concerns as to whether it delivers rewards that can substantiate its initial high cost of implementation. Our research will attempt to justify this investment in terms of resulting benefits for students, staff and academic members as a whole. To put things in technical perspective, we focus only on the implications of the virtualization platform on academia. The environmental configuration consists of hardware with a host OS, virtualization software and series of virtual machines. A citrix configuration [4] was utilized. Some important technical implications of such a deployment include:

- In the main office, the console is set up on a computer that is close to the server for fast data collection. This is referred to as the Presentation server. The IT department at the university must create user accounts for each remote user. These users can then access the console quickly over HTTPS to improve security.
- The university can benefit from load-balancing to spread the remote accesses.
- The main bottleneck for a console running on Citrix is memory size. If the console (in a computer lab or in an academic faculty office) runs out of memory, its performance decreases sharply which results in some application crashes (as will be noted in some negative student experiences).
- The second constraint is CPU power. During refreshes, the console works best with a full CPU core. This implication would be evident in extensive interviews with academic staff running CPU intensive applications.

- The final concern is disk space for the console cache. There should be enough disk space to provide one cache file for each console operator. This requirement results in some negative side effects on individual student consoles in computer labs.

2.1 Research Questions

Leading from the above problem statement, our research focus was centered on the following research question: "What is an optimal framework for measuring the Effects and implications of Virtualization on an academic institution?" We start by considering the effects of virtualization as an application of cloud computing on academic institutions. The aim of this research is to discover the fundamental approaches used in the deployment, lease and workload, as well as the utility, benefits and justification of this technology in an academic institution. The research extended the literature on studies conducted at a few prominent U.S universities that already employ virtualization technology. However, from the literature and previous works done on virtualization in academia, there have been no known framework for measuring the effects of Virtualization on academia. In this paper, we provide an appropriate framework which can be utilized to assess the effects of Virtualization in an academic institution. This research focuses on capturing and analyzing the student learning curves, work load, usability of virtualized applications and privacy amongst others to eventually validate its positive and/or negative outcomes.

2.2 Significance of This Study

Virtualization technology has been noted to be one of the contemporary and pioneering trends in information technology today. As such, it is relevant to carry out a research study to analyze the optimal deployment of the virtualization infrastructure as well as to view the benefits and effects which this state-of-the-art technology can bring to other institutions in the UAE as well as other parts of the world. This study can help other business ventures, especially educational institutions such as universities looking to adopt virtualization technology in their enterprise, by providing relevant information entailing the outcomes and consequences in adopting this technology to assist decision-making by stakeholders. We provide intricate analysis on the perceived and categorical perspectives on the usefulness, effectiveness and value of this technology in an academic environment using statistical analysis.

3 Related Work in Virtualization

Virtualization technology supplements cloud computing and can is considered as a set of software tools which divides a server into virtual resources called Virtual Machines (VM's) reducing power and expanding computing resource allocation and data storage [3]. Applications running within an Operating System (OS) independently can also be configured using virtualization. Cost effective solutions for academic institutions has been a major driver in current decision making. Chawdry and Lance [5] discussed

computer virtualization techniques used at a university in California University highlighting the potential paybacks virtualization can offer to academic institutions. They also explained the IT infrastructure needed to successfully implement such innovative tools. Condensed costs and minimized energy consumptions were the two key benefits highlighted. Microsoft, Citrix, and VMware were discussed as possible solutions and how the size and structure of the different universities would require different settings for the virtualization deployment to maximize benefits. The virtualization concept started in 60 s where it was explained that different operating systems can potentially be installed in the same computer [6]. The concept of the virtualization was widely expanded since then [7] distinguishing between different virtualization types. Academic institutions usually allocate an IT budget to develop new software/hardware solutions as we as maintain existing IT solutions to maximize technological benefits in the teaching and learning process. The high costs of existing desktop computers as well as the complex network configurations and software licenses result in a careful re-thinking of existing IT deployments. A number of researchers have investigate the use of virtualization in universities worldwide. For example, [9] discussed how teachers used virtual network labs to teach an IT course. The authors in [8] discuss the concept of a virtual computer laboratory where students can access tools virtually. The authors in [10] investigated the use of virtualization in a management information security course. [11, 12] discussed the effective uses of virtualization in different contexts to deliver course learning outcomes. In [13], the authors discussed the deployment and implementation of a unique innovative virtualization infrastructure used for educational training allowing remote access to software tools using a web portal. They discussed the use of a hypervisor which isolates each server's virtual machine protecting the different virtual machines from each other. Desktop virtualization provides a solution to this problem by enabling older operating systems the ability to install and run applications that are only compatible in newer operating systems. The remarkable improvements virtualization brings to educational applications are nowadays widely documented and consolidated. Castiglione, et al. [14] explained how visualization can be used to increase the course learning outcomes by providing exercises to the students which they can access using PCs. Garcia et al. [15] described different hosting technologies that can be used to build up a suitable virtualization infrastructure in an academic environment. A university learning lab was thoroughly discussed as an example to showcase the virtualization potentials. The separate components of the lab were summarized.

To summarize, existing research on virtualization have discussed the fundamental benefits derived from the adoption of this technology in the academic environments including the choice of various vendors specializing in virtualization technology and what features (e.g. cost, compatibility with existing IT infrastructure, etc.) influenced their selection of a particular vendor. However, no existing work has provided a framework to test the implications of the use of such technologies on the performance of the students and existing teaching methodologies.

4 Research Methodology and Analysis

Our research will include quantitative analysis and the target population is set to be university students and faculty staff members. We would like to investigate the perceived benefits of virtualization at the university and its implications on the aforementioned stakeholders. We conducted a series of interviews, surveys and correlated research searches to discover firsthand the virtualization technology effects on past and current students as well as on academic staff. The sample frame for the survey was selected from current student and faculty staff directory. This provided adequate means to reach all registered students and staff to deliver effective results.

4.1 Sample Size and Description

The population selected for this research consists of all enrolled and currently registered students as well as faculty members of the university. The plan for selecting sample units includes:

(a) a manual cluster sample survey for students where 300 enrolled students in random cluster classes (final year classes and newer classes) were asked to fill a survey accurately.
(b) a manual survey/interview for faulty members where five randomly selected non-IT faculty staff members and five randomly selected IT faculty staff members were interviewed and surveyed.

4.2 Proposed Survey Measures

Based on prior research, we summarize our theoretical framework in Fig. 1. Our framework includes significant measures and attributes of virtualization on the students as well as on academic staff. These attributes were divided into five main categories including: (i) Accessibility; (ii) Usability; (iii) Privacy; (iv) Performance and (v) Applications. More specifically, the interviews conducted for the faculty members were standardized open-ended interviews for the IT and Non-IT faculty member while the questionnaire for students focused on answering the following questions (and sub-questions): "Does virtualization have effect and to what degree on:"

(1) Student general academic performance.
(2) Ease of access of online material for both student and staff.
(3) Usability and satisfaction when accessing applications and academic materials online.
(4) Convenience in Accessing virtual computer labs and MyDesktop online.
(5) Student and staff credential security and Privacy when accessing virtualized platforms.
(6) Effect on staff for enabled Access to document management system within and outside the campus, caused by campus virtualization (RMS).

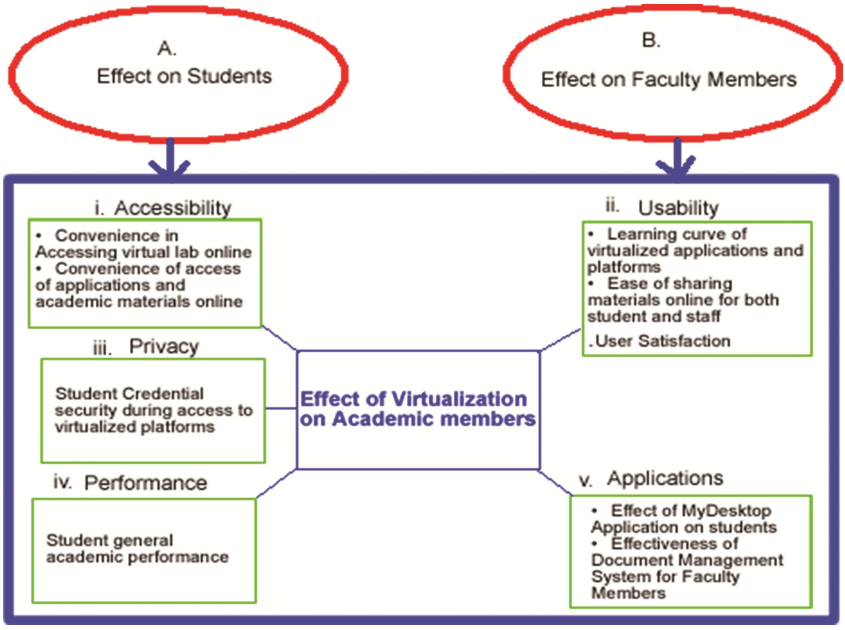


Fig. 1. Framework for measuring the effects of virtualization on academic members

We also divided our questions into the different categories as follows:

1. *Experience/Behavior Questions*: Aimed at eliciting description of experiences, behaviors, actions and activities that would have been observable had we have been present. Examples of questions asked included: If I had been in the program with you, how would we have utilized virtualization in a project? What experiences would I observe you having in an assignment requiring an application not available in your local pc?
2. *Opinion/Values Questions*: These questions are aimed at understanding the cognitive and interpretive processes of the students as well as the academic staff.
3. *Feeling Questions*: These questions are aimed at understanding the emotional responses of the students/staff to their experiences and thoughts.
4. *Knowledge Questions*: These questions try to find out what factual information the students/staff has. Examples included: What are some of the rules and regulations of the virtualization program? What kinds of services are provided?
5. *Sensory Questions*: The purpose of these types of questions is to allow us to enter into the sensory apparatus of the students/staff. An example of questions asked included: Describe to me what I would see if I was using the virtualization tools at your university?
6. *Background/Demographic Questions*: These questions concern the identifying characteristics of the student/staff being interviewed.

4.3 Data Collection and Analysis

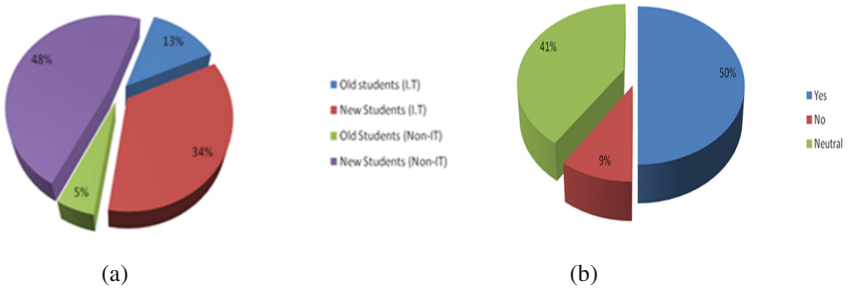
The surveys were broken down into two parts, interviews with selected faculty members and hard-copy questionnaire surveys delivered to enrolled students to complete in their classes. For the manual hard copy questionnaires, we used cluster sampling (probabilistic) where we selected random classes for students. Convenience (non-probabilistic sampling) was used for interviews with selected Faculty academic staff. The survey was carried out over a period span of two weeks. Questionnaires were distributed to students in their classes for courses based on two major categories:

A. New students (IT and non-IT majors) who got enrolled after implementation of campus virtualization, and
B. Old students (IT and Non-IT majors), who have been enrolled prior to the implementation of virtualization.

The groups were verified based on their subject code enrolled in the current semester and through this we were able to identify the old from the new students as well as IT from non-IT students. For the faculty members, interview sessions were conducted with three Associate Professors from the Faculty of Computer Science and Engineering and two Associate Professors from the Faculty of Business and Management. After conducting the surveys, 223 accurately completed student questionnaires and 8 uncompleted student questionnaires were received.

4.3.1 Statistics Relating to Students

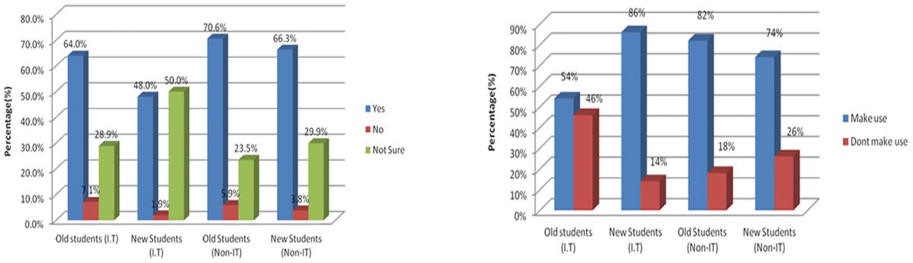
- Virtualization platforms are effective and new non-IT students access it weekly more than other categories of students as shown in Fig. 2(a).
- Half of the students are satisfied with the user experience of virtualized platforms. 41 % are unsure about it with most stating reasons such as interface issues and slow performance as shown in Fig. 2(b).



(a) (b)

Fig. 2. (a) Weekly student usage of virtual platforms; (b) Overall student satisfaction.

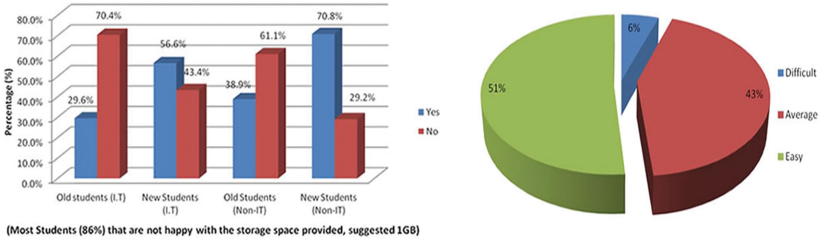
- Except for newer students that are unsure about privacy, on average, 79 % of the students feel their credentials are secured when accessing VDI platforms (Fig. 3(a)).
- More than 50 % of students make use of VDI platforms in their course work and assignments as shown in Fig. 3(b).



(a) (b)

Fig. 3. (a) Student perceived credential security using virtual platforms; (b) Effectiveness of VDI on student course work (Usage).

- Generally newer students are more satisfied with the Virtual storage space of 100 MB provided than senior students as shown in Fig. 4(a).
- Students averagely have good accessibility but some face login errors, Virtual labs PC freezing and lag in some applications as shown in Fig. 4(b).



(a) (b)

Fig. 4. (a) Student Satisfaction with VDI provided storage space (100 MB per student); (b) Student ease of accessibility to virtual computer labs.

- Overall 80 % of students feel virtualization has helped them in better communicating with their lecturers. However, the other 20 % unanimously expressed their dissatisfaction in that the virtualized platforms provided for communication was only suited for a one-way medium – from lecturer to student and not the other way around.

4.3.2 Statistics Relating to Academic Staff

- ***Seamless Transition:*** All interviewed faculty members alleged that there was no perceived difference in the new virtualized systems implemented as opposed to the older traditional system as there was an absolute and seamless transition.
- ***Performance Issues:*** Especially for IT faculty staff and students, high Memory Utilization Apps such as RobotC, Arena, Matlab, Lightwave and Unity tend to have declined performance having been virtualized. These virtualized lab applications are generally slow, and seen as highly time-consuming by its users. This leaves the

academic members who utilize these virtual apps frustrated as well as giving the new I.T students a bad impression about the course offered.

- ***Access:*** Virtualization provides improved/convenient access to academic materials off-campus. However, there is lack of control for some virtual apps especially ones used by the IT faculty. Some apps such as Cyber-cage, which is a 3D scenario based IT security application used, may require some admin modifications to its configurations. Virtualization prevents such modification to be accomplished, leaving IT faculty members frustrated.
- ***Interface:*** 60 % of faculty members interviewed expressed that even though they utilized some virtualized platforms, the Interface is unsatisfactory and in some cases cumbersome. They stated that virtualized platforms such as RMS, and WebMail can and need to be improved in terms of the interface and usability.
- ***User Rights:*** 50 % of interviewed IT faculty member stated that RMS, which is a document management system used by faculty members to share documents, has some difficulty in enabling user-rights to documents intended for sharing and furthermore suggested that granting of rights should be made more transparent in the RMS interface.
- ***Storage:*** Due to Virtualization, there is improved effectiveness especially with the greater email storage space provided by the technology.
- ***Security:*** The interviewed faculty members pointed out that security and privacy remains uncompromised with virtualized platforms, however a general sense of insecurity remains with the fact that their data is stored remotely away from their close and immediate reach with virtualization.
- ***Licensing:*** For Academic members, virtualization technology provides access for utilizing applications online. However, there is a limitation in that some applications cannot be accessed off-campus due to license restriction. Therefore, the faculty members express their hopes for future availability of licenses for those applications which they and their students would immensely benefit from if virtualized and made available remotely off-campus. Such applications include Matlab, Arena and Lightwave.

In an extended version of this research, inferential hypothesis test results would be presented regarding the effectiveness of virtualization in academia.

5 Conclusions

We can conclude that virtualization is effective in academia as proven by the developed framework and survey analysis conducted within the campus. Student and faculty member feedback yielded positive results, even though the majority expressed that there is room for future improvement concerning availability of licensed applications, usability of interfaces, and performance of some specialized virtual lab applications with the implemented virtualization technology. Conclusively, we hope to see more and more universities move on to adopt virtualization technology in their campuses as an application of cloud computing to improve convenience and efficiency of academia as well as save costs in the IT infrastructure development and maintenance in the long run.

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