The Effect of Adopting Virtual Machines and Multiple Operating Systems in Improving the Quality of Higher Education in Developing Countries

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Virtual computing is considered one of the main solutions that may improve the quality of information technology services. This technology may offer several benefits for students such as dealing with a complicated situation and technical troubleshooting as well as sharing resources. It delivers numerous computing services by installing several operating systems in one physical machine. However, despite the benefits of adopting virtual machines, there is still limited usage of this technology in higher education institutions in developing countries. This research will shed light on the adoption of virtual machines at higher education institutions in the Kingdom of Jordan. An interpretive paradigm using triangulation methods was applied to collect data from five universities in Jordan, thirteen semi-structured interviews were conducted along with two focus groups, 233 surveys, and direct observation. The data was analysed using Nvivo software, and Microsoft Excel was used to present the statistical results. A proposed framework has been developed and validated to suggest a roadmap for adopting virtual machines in Jordanian universities. Five factors which are cost, trialability, awareness, maintenance, and backup have been identified and incorporated in the framework.

Keywords: Higher Education, Developing Countries

Introduction

Virtual machines considered as computer software aim to provide a real simulation architecture of physical machines. It could be argued that the technology of virtual machines started in the 1960s through developing compatible time-sharing systems (CTSS). Time-sharing provides the ability to use the same computer as each application appears to execute at the same time but in reality, one program is executed and the system switches to another program. The notable evolution of virtual machine technology started via the IBM research centre where they created full virtualisation applications such as hypervisor computer software in the 2000s.

VMware was one of the most important virtual machine software founded in 1998, which intensively used a solution for virtual operating systems that could run on one physical computer at the same time. In addition, VMware provides several solutions for virtualisation of education such as digital transformation for higher education, virtual data-centres, and digital workspaces for students. Moreover, it provides a considerable amount of free online courses for students and lecturers to improve the quality of IT services in the higher education section. In developing counties, such technology may play a major role in enabling digital equality as it may provide the chance to all interested students to access advanced applications securely from any device. It also provides the ability to access the university resources remotely from any place during off-hours.

The usage of desktop virtualisation in higher education provides several key benefits such as centralised management for local machines and simplified help desk support. In addition, it offers high-performance computing for students to get fast access to education materials and a high-level response time. Moreover, this technology help universities to reduce hardware, software and energy costs. Accordingly, students may use their smartphones or laptops to access servers with high-performance capabilities instead of creating more computer labs.

Windows Azure is another important virtual machine solution, which is provided by Microsoft and started in 2010. It provides several services for business departments as well as developers based on cloud computing technology such as creating web sites, internet services, AI platforms, SAP on Azure, Blockchain, hybrid cloud applications, Oracle on Azure, virtual machines applications, E-commerce as well as backup, archiving and disaster recovery solutions.

All these services and solutions are mainly based on using virtual machine technology in addition to cloud computing. For instance, windows virtual desktop is considered a comprehensive desktop solution that provides multi-operating systems and applications using multiple sessions to migrate windows servers with several remote applications based on cloud computing technology. Furthermore, for high-level workloads and enterprise solutions,

windows azure provides a virtual machine that may contain up to 416 virtual CPUs and 12 TB memory. Such a solution could handle a large company that includes hundreds of employees with thousands of active customers.

The business model of the payment method is mainly based on pay-per-use. Therefore, users can pay per hour instead of buying expensive servers, which may cost thousands of dollars. Moreover, the maintenance, support and upgrade responsibility of such servers will be from the service provider side. According to Masdari, Nabavi, & Ahmadi (2016), the usage of virtual machines promises to make high-cost savings for enterprise companies, especially in energy.

Cloud Computing and Virtualisation

Cloud computing technology is considered an umbrella to all the virtual resources available on the internet. Accordingly, cloud technology offers a shared pool of virtual resources that could be used by individuals or companies such as data storage, data analysis, data processing, and customised applications and services. Cloud computing enables ubiquitous and on-demand access to virtual hardware and software resources based on the pay-per-use business model. This model is similar to traditional payment methods for public utility services such as electricity, and gas. Accordingly, cloud technology promises to deliver almost zero up-front costs as well as decrease the overall costs in short and mid-term usage.

The maintenance of such resources will be from the service provider side, which allowed customers, such as enterprise companies, to focus on the business itself instead of wasting company resources on technology troubleshooting. Moreover, scalability and elasticity could be another important feature in cloud technology. Scalability could be defined as flexibility in increasing and decreasing the number of resources based on the workload requirements, while elasticity is the ability to dynamically increase or decrease the quality of services.

Cloud computing can be classified into service models and deployment models. Such classifications are according to computing requirements form the customer side. Cloud competing models consist of several layers, based on the architecture design of the cloud computing service providers. There are three main types of cloud computing services models, as follows: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (Armbrust et al., 2010). Deployment models are classified as follows: private cloud, hybrid cloud, public cloud, and community cloud computing (Odeh, Mahmoud M., 2019a).

Higher Education in Developing Countries

Developing countries usually suffer from the underutilisation of adopting information and communication technology in general and cloud computing virtual machines in particular (Sabi, Uzoka, Langmia, & Njeh, 2016). Such underutilisation of technology has negatively affected several sectors, including higher education (Odeh, Mahmoud, Warwick, & Cadenas, 2014). Stein, Ware, Laboy, & Schaffer (2013) argued that cloud computing virtual machines can improve the quality of higher education as well as reduce the cost. Such an argument has been observed in several developing countries. For instance, Microsoft has rolled out more than 250,000 laptops with windows Azure operating systems in Ethiopian higher education institutions (Sultan, 2010). Such laptops enable lecturers to upload and download curricula securely. The adoption of Windows Azure helps higher education institutions in Ethiopia to reduce the overall cost of hardware and software such as data centres.

Furthermore, an extensive study conducted by Shirazi, Gholami and Higón (2009), which aimed to investigate the impact of adopting advanced information technology on the social economy of eleven countries in the Middle East, argued that there is a strong influence between economic growth and the adoption of information technology in higher education institutions.

However, Truong, Pham, Thoai and Dustdar (2012) found that universities in developing countries experienced many challenges, such as the limitation of computer resources which leads to strong competition among students to use such resources. Furthermore, expensive and high-quality computer resources are usually unavailable. The unavailability of advanced resources leads to a lack of creating complicated experiments as well as a lack of solving advanced scientific problems. Moreover, the computer labs are only available during class hours with a maximum of eight hours per day. This could negatively affect the knowledge sharing between lectures and students outside business hours.

Virtual machines cloud computing could be used in higher education institutions in developing countries using the same approach in developed countries (Sabi et al., 2016). As a proposed solution for limitations of computer resources, cloud computing promises to provide almost unlimited resources at a low cost, which can be accessed from anyplace, using any device, at any time (Yangui et al., 2016). However, the adoption of cloud computing technology requires a well-prepaid infrastructure such as high internet speed to download and upload data (Odeh, Mahmoud M., 2019a).

According to Truong et al. (2012), in developing countries, the barrier to adopt virtual machines cloud computing could be the on-line payment method. Scholtz (2016) argued that the lack of awareness of the benefits of virtual machines cloud computing is another main barrier to the adoption of such technology. However, Sabi et al. (2016), stated that security and privacy is

considered the most important barrier to the usage of cloud technology. The lack of technical experts in virtual machines cloud computing technology could be a barrier in the process of this technology adoption (Truong et al., 2012).

A study conducted by Massadeh, Al-Lozi and Darawsheh (2013) found that higher education institutions in Jordan could benefit from the adoption of advanced online technology such as cloud computing. Several factors may influence the adoption of cloud technology and virtual machines such as compatibility of current technology, complexity, privacy, and security (Othmana, Rahimb, & Sadiqc).

Jordan, the Context of This Research

Jordan is a small developing country in the heart of the Middle East which always seeks to improve the quality of higher education by adopting information and communication technology in both undergraduate and postgraduate levels. Statistically, there are 21 private universities and 10 public universities in Jordan. According to statistics conducted by Badran (2014), there are 310,606 undergraduate students, 14,783 postgraduate students, and 2,362 PhD students in Jordanian universities. In 2007, the higher education accreditation council was established to improve the quality of Jordanian higher education. The adoption of virtual machines cloud computing technology in Jordanian universities could be one of the methods that may improve the quality of higher education by offering advanced technology for both students and lecturers.

Research Methodology

To explain the research methodology, data collection process, and data analysis, this section presents the methodological approach and research design employed in this study. The data was collected from five higher education institutions in Jordan. By conducting thirteen semi-structured interviews, two focus groups, 233 qualitative surveys, and direct observation and analysis, this study mainly applied qualitative methodology using an interpretive stance. The direct observation and analysis included five servers, eight laptops, and nine desktops. Accordingly, this study adopted case research, which usually employs several data collection methods. Case research is strongly recommended when the study is complicated and needs a deep understanding of each factor. Moreover, case research enables the researcher to create and develop new theories and frameworks to solve through triangulating the data collection method.

Ethical considerations were taken into account in this study to avoid any ethical conflict that could arise from the nature of such qualitative research. Therefore, the researcher received ethical approval from the Zarqa university ethical panel. Such ethical approval includes several

issues such as the researcher meeting the participants at a convenient time for them, all of the participants being informed about the aim of this study, the researcher informed the participants about the expected time required for the interviews or surveys, and the researched informed the participants that they have the right to withdraw during the interview or when filling out the survey without any justification.

Main Results

The data analysis process in this study was based on three steps recommended by Miles and Huberman (2014), which included data condensation, data display, and drawing/verifying conclusions. Microsoft Excel and Nvivo software were used to present the results such as main factors, nodes, and frequencies or statistics. This study found that several factors may play a major rule in the adoption of virtual machines at higher education institutions in Jordan as follows: cost, trialability, awareness, maintenance and support, and backup and restore.

Cost

The deployment of virtual machines based on cloud computing technology could be heralded as a solution that decreases the overall cost of usage of information technology at any institution (Jones, 2015). Cloud computing service providers argue that adoption can improve service quality as well as reduce costs. This could be achieved by 24/7 availability of cloud services at any place using any device with almost zero downtime. However, the internet connection should be available for cloud service while virtual machines and multiple operating systems can work in off-line mode and using the patch process for transferring data as soon as the machines connect with the internet.

The feedback from the participants has shown that the cost benefits of adopting several operating systems on one physical computer constitute a significant factor in this study. The majority of participants stressed that installing several virtual operating systems and improving one computer would greatly improve the cost (see figure 1). This can be compared with the cost of using several computers with only one operating system on each device. Such a process could be achieved by a focus on one machine through increasing the random-access memory, using a high-speed central processing unit, and adding more solid-state hard drives. Furthermore, integrated cloud computing services with such machines to handle data storing and processing will improve the overall cost as well. To explain the previous argument, one of the participants gave an example as follow:

The cost benefits of using virtual machines are very clear. Simply, we have installed 11 operating systems in dell server power edge R730 with 64 GB RAM and 8 core CPU. The cost of this server was $3466. However, if we install these 11 operating systems on 11 computers

the cost would be around $600 for each computer, which means that the total cost will be $6600. Therefore, the saving cost was $3,466 (52.5% saving).

On the other hand, the findings show that 74% of participants believed that the adoption of virtual machines based on cloud computing would decrease the cost, whereas 17% believed that the adoption of virtual machines would not decrease the cost, and 9% did not know.

Figure 1. The effect of virtual machines on the cost of information technology
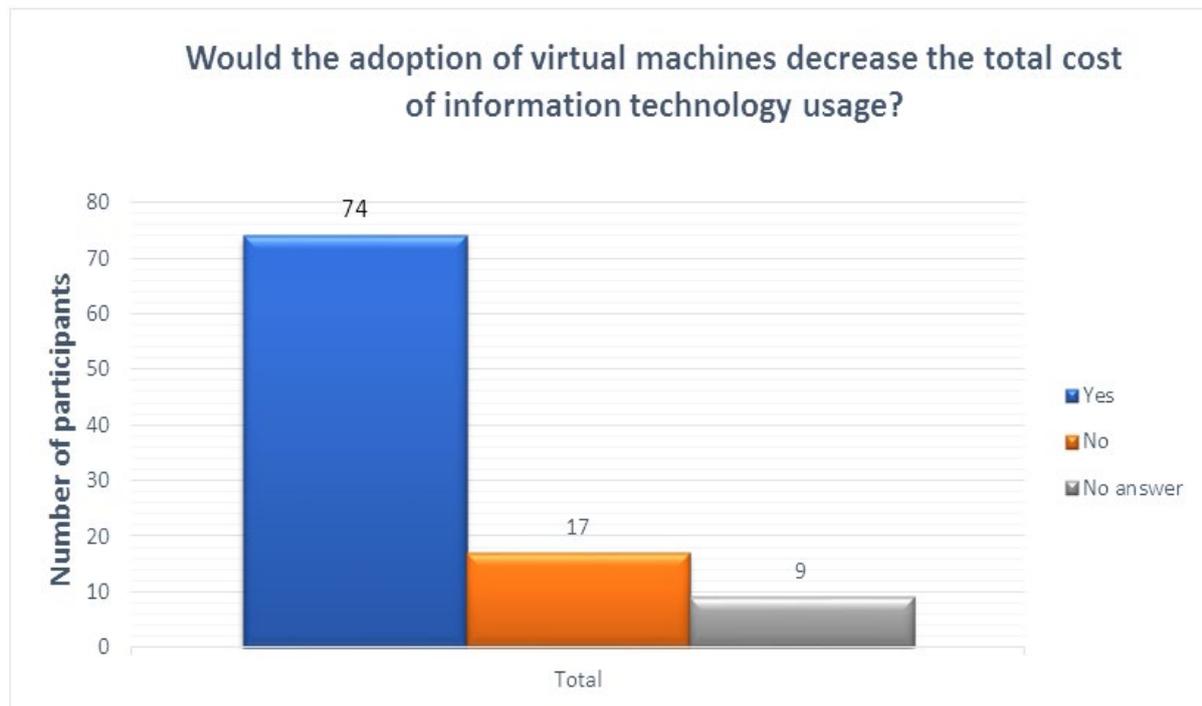

Trialability

Trialability refers to the ability to which the software has a free pre-adoption option for testing purposes from the client-side (Odeh, Mahmoud, Warwick, & Garcia-Perez, 2015). A trial version of any software would increase the familiarity of such software with end-users before the process of full adoption (Jamsa, 2012). It could be argued from this study that most of the participants prefer software with a trial version before full installation. In addition, this research showed that trialability has a direct connection with the benefits of using virtual machines. The ability to use any software for a specific period enables the end-users to discover the benefits and limitations. One of the IT managers stated that:

It is very difficult to make a judgment on any software without a trial version. Therefore, trying virtual machines and cloud technology would help both end-users and companies to decide

whether to buy the solution or not. However, despite the benefits of virtual machines and cloud computing solutions, the decision should be taken carefully especially for long-term usage.

Furthermore, as can be seen from figure 2, 64% of participants preferred software with a free trial version and believed that such feature may have a direct influence on the adoption of virtual machines technology. Whereas 22% of participants cannot see any direct influence between trialability and virtual machines software, and 14 did not know.

Figure 2. The role of trialability on the adoption of virtual machines
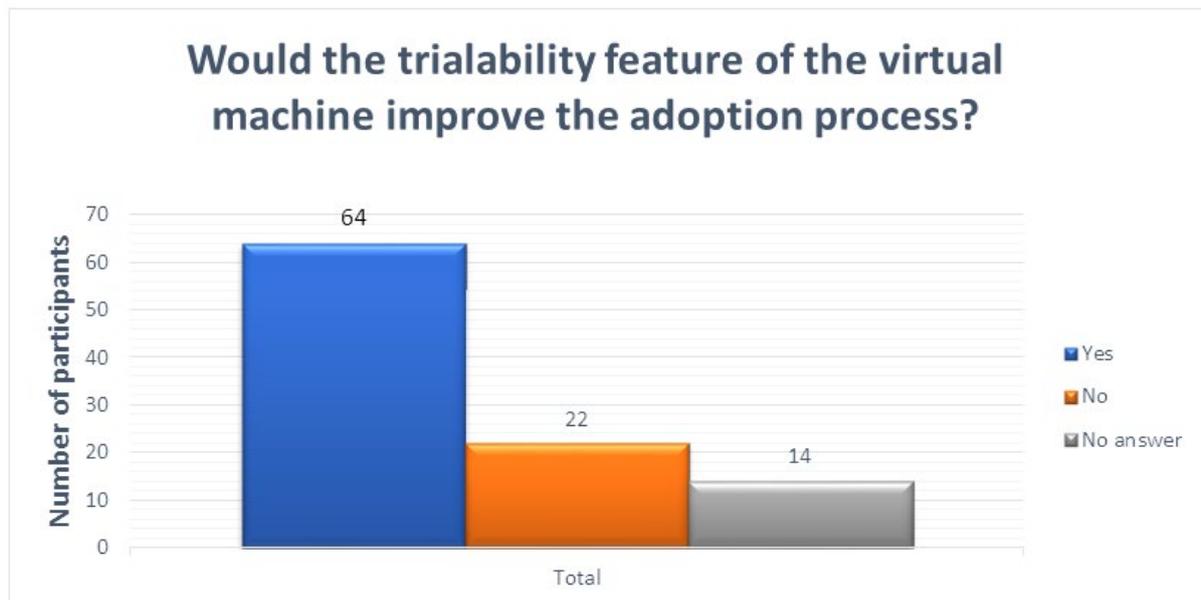
In brief, almost all interviewees and the majority of survey participants supported the importance of trying virtual machines before the decision of full installation. The adoption of the trial version could avoid any disappointment as well as providing a better understanding of advantages and disadvantages.

Awareness

Awareness about the benefits and limitations of virtual machines using cloud technology is considered as one of the most important factors that influence the adoption process. Awareness includes the basic characteristics of the virtual machines business model based on pay-per-use in the case of connecting with cloud computing technology. According to Roger (2010), awareness of the innovation is the first step of the adoption process. If the higher educational institutions in developing countries become aware of innovative technology such as virtual machines, then the chance of adopting such technology could be increased.

Most interviewees in this study argued that the lack of awareness could be the main reason for the limited adoption of virtual machines and cloud technology. As one of the interviewees said:

I strongly believed that the lack of awareness about the innovative technology and its benefits especially from the top management side in this university is the main reason that prevents the adoption of virtual machines.

In brief, it could be argued that awareness of benefits and limitations of innovation technology plays a significant role in the process of adopting virtual machines at Jordanian higher education institutions.

Maintenance and Support

Maintenance and support are important factors in this study; this refers to the hardware and software failures. Virtual machines, which host cloud computing technology has a great benefit in this area as the technical support issues will be from the cloud service provider side (Jamsa, 2012). The other benefit of cloud technology is that the software and hardware upgrades will be the responsibility of service providers.

Direct observation shows that most of the laptops, desktops, and servers were installed with VMware software or other virtual software as a solution to install several operating systems in one physical machine as well as other virtual machines based on cloud technology using Windows Azure. However, in this case, it could be argued that maintenance and support would be easier compared with the traditional approach. A professor from one of the engineering schools in Jordanian higher education institutions supporting this argument stated:

It is easier for me to make technical support for one server instead of 8 or even 10 computers. Furthermore, it is also easier to distribute the resources between virtual machines such as adding more RAM or storage. This feature reduces the time of maintenance and support. Moreover, connecting the server and virtual machines with cloud computing for using cloud features would make the technical support much easier as well.

Interestingly, 82% of participants believed that the usage of virtual machines based on cloud technology would improve the maintenance and support efforts. Whereas, only 11% of participants argued that the adoption of virtual machines would not create a big different for this factor. However, 7% are not sure if virtual machines would influence the maintenance and support factors.

Figure 3. The role of adopting virtual machines on improving maintenance and support processes.

Would the adoption of virtual machines improve the maintenance and support efforts?
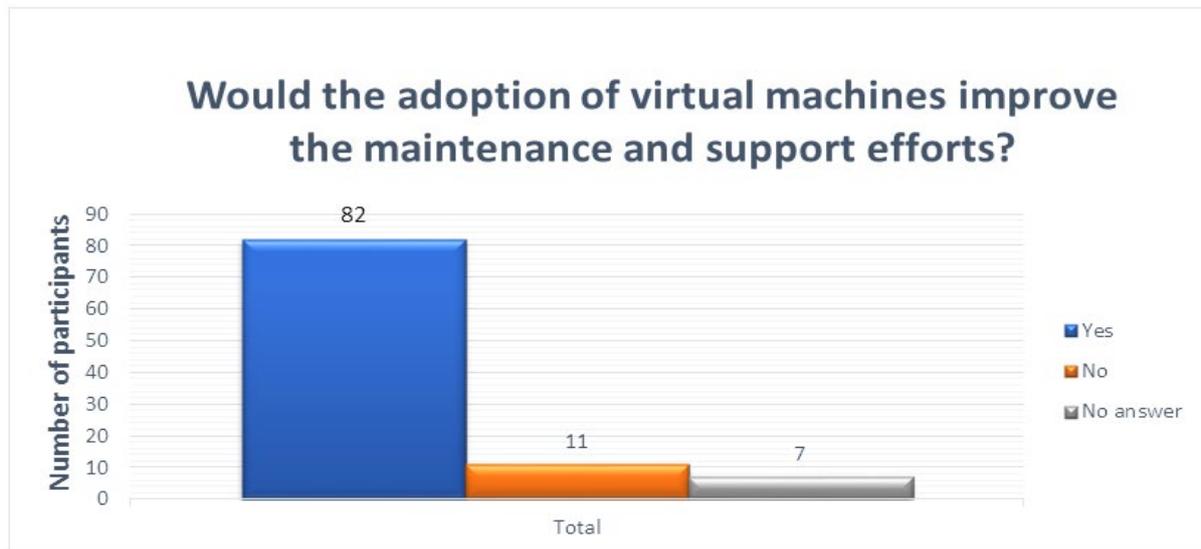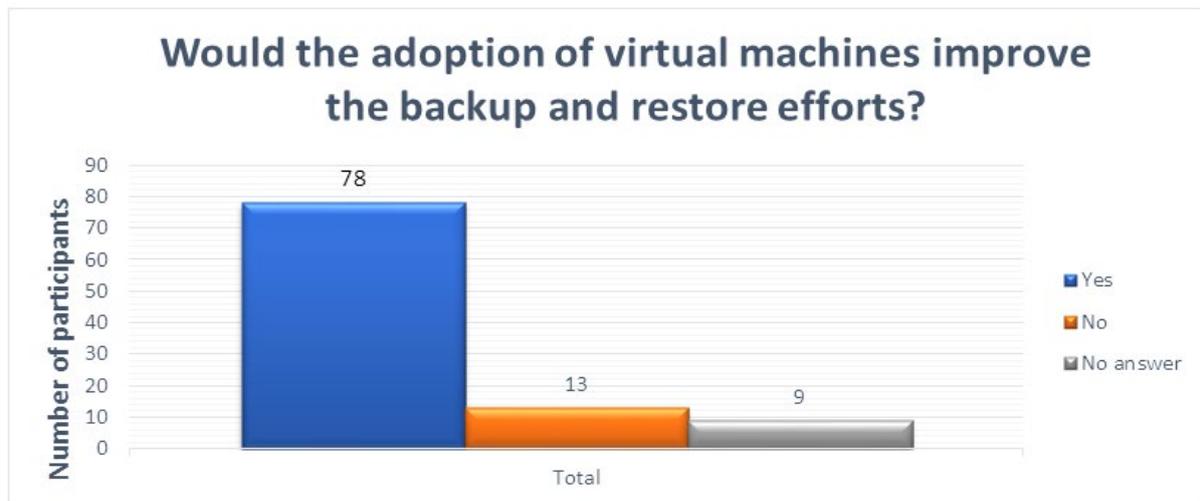
Backup and Restore

According to the direct observation by researchers in this study, Jordanian universities continue to seek effective solutions for the process of backup and restore. A great benefit could be gained by virtual machines and cloud technology in this area. The virtual machine could be transferred easily from one computer to another. Therefore, the whole platform with applications and operating systems could be backed up and restored easily. Cloud computing technology provides a wide range of remote and automated backup services with bargain prices. Supporting this point of view, an IT manager at one of the private Jordanian universities stated:

When we (are) talking about cloud technology and virtualisation, backup and restore is my favourite part. Several years ago, it was a very difficult task as I had to stay one or even two hours after the employee leaves to be sure that all data has been backed up. It was a manual process using a backup tape drive. Nowadays, it is a simple schedule task by cloud computing technology. The benefit of using a virtual operating system is that you can create a full copy with all applications. The operating system can be restored with all platforms within less than 30 minutes.

Findings from the survey showed that the majority of participants believed that backup and restore services have a positive influence on the adoption of cloud technology and virtual machines (see figure 4).

Figure 4. The role of backup and restore on the adopting of virtual machines


The finding from this study agrees with, who argued that the benefits of backup and recovery feature when using cloud computing technology. Therefore, backup and restore factors may have a positive influence on the adoption of virtual machines and cloud technology at higher education institutions in Jordan.

A Proposed Framework

This framework aims to suggest a blueprint for the adoption of virtual machines based on cloud computing technology in Jordanian higher education. At the beginning of the adoption process, it is important to improve the awareness level of virtual machines. The second step is the decision of selecting a suitable virtual machine application for higher education. The third step is to select the suitable deployment model and service model of cloud computing technology, which will be connected with virtual machines. The fourth step is to select a suitable backup and restore plan. And the final step is to plan for the long-term process, which includes updates, upgrades, and maintenance if required.

Figure 5. A proposed framework for adopting virtual machines based on cloud computing
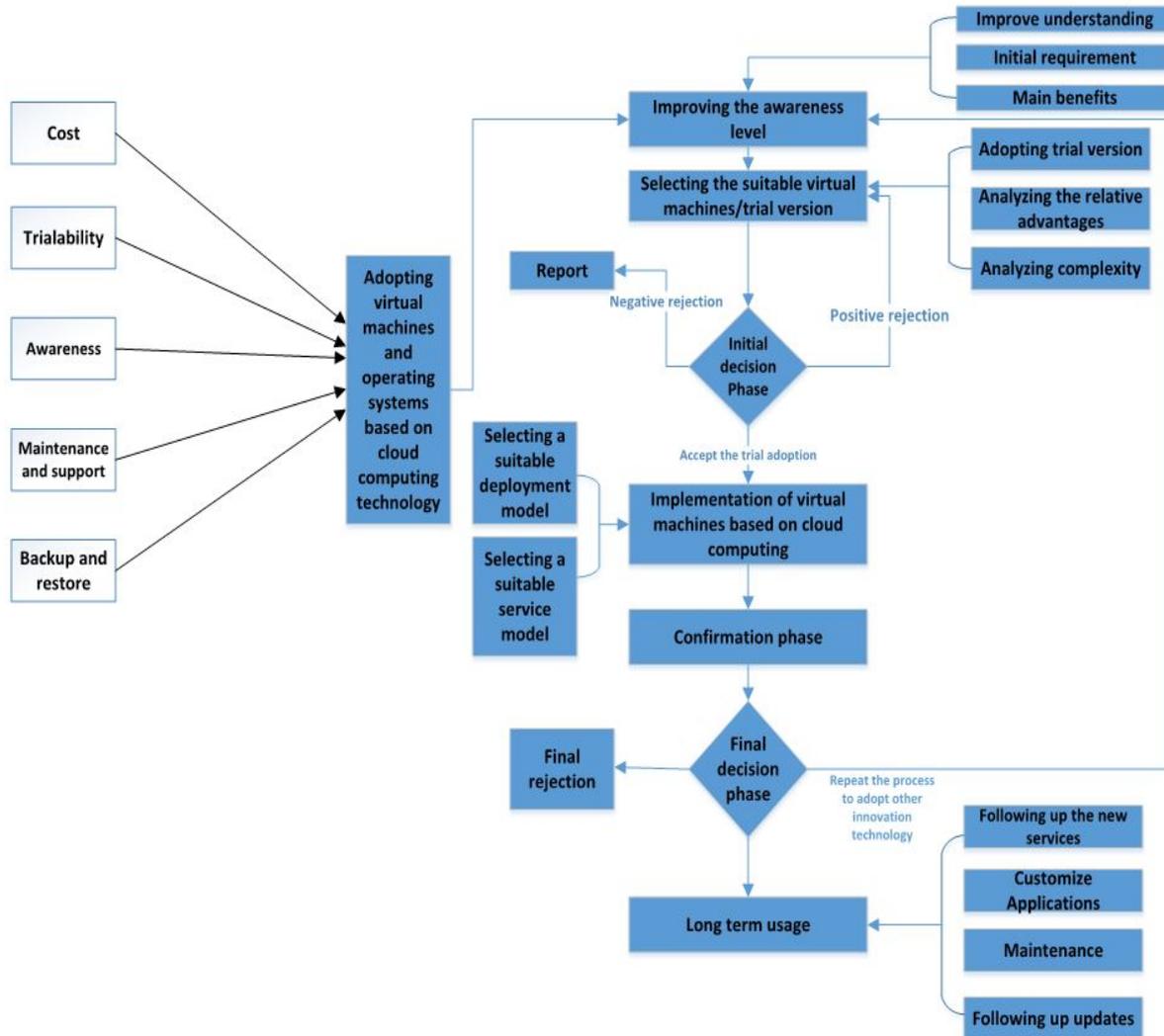
Framework Validation

Framework validation is an essential step in improving the quality of the framework as well as to determine the reliability of the research result. Odeh (2019b) recommends selecting validators who have deep experience in the research topic. Authors of this study contacted thirteen potential validators based on their experience and technical background. However, five validators accepted the invitation. Table 1 shows the evaluators' professional background and years of experience.

Table 1: Validators profiles

| Validator #	Professional background	Years of experience
Validator 1	Information manager	22 year
Validator 2	Professor in computer science	16 years
Validator 3	Professor in management information systems	18 years
Validator 4	Senior assistant professor in information systems	6 years
Validator 5	Associate professor in computer engineer	11 years

Figure 6. The framework validation process
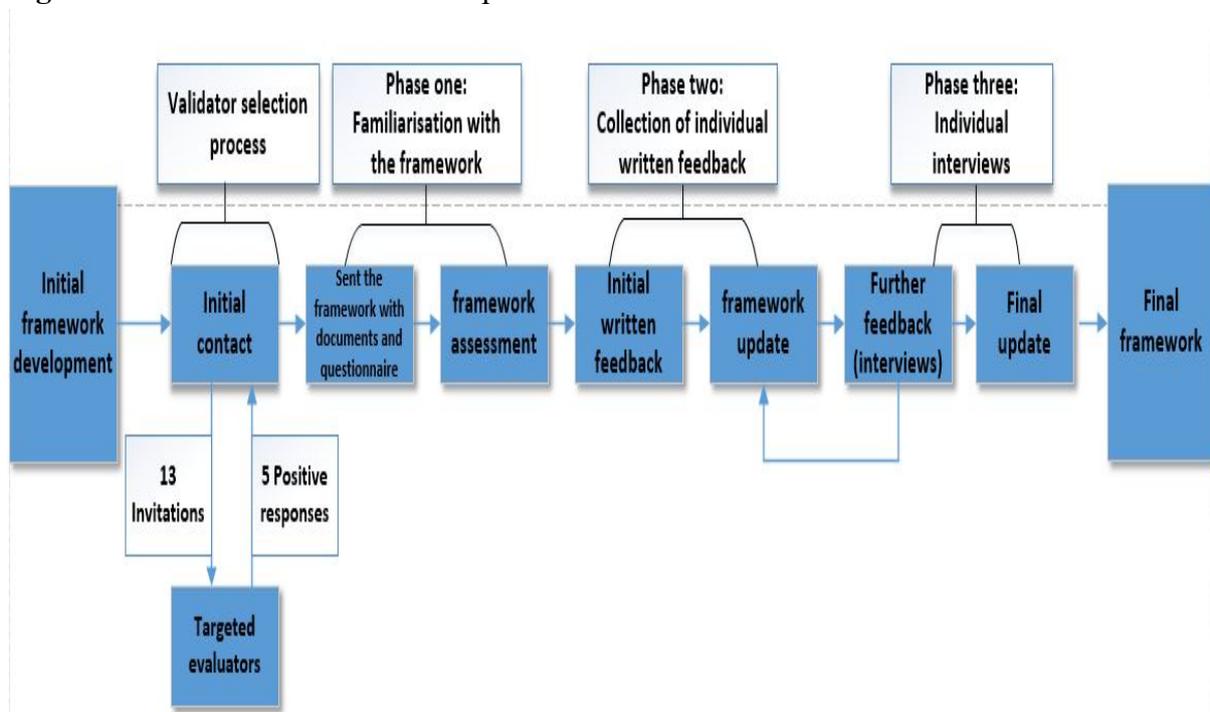
Figure 6 presents the overall process, which undertaken to carry out the process of validation with time framework. The framework validation process consisted of three phases. The first phase is familiarisation with the framework by reviewing documents, questioner, and the framework itself by evaluators. The second phase aimed to collect the feedback and comments suggested by evaluators. The third phase aimed to send back the framework with updates based on their feedback and comments for the final check and further feedback. The final feedback has been taken through conducting interviews with evaluators for finalising the framework and making the final updates. All corrections and feedback have been added to the final version of the framework, which is already shown in figure 5.

Conclusion

Despite the intensive adoption of innovative technology, limited studies have been focused on the use of virtual machines and virtual operating systems by higher education institutions in developing countries. This paper investigated the rule of adopting virtual technology in improving the quality of higher education institutions in Jordan. This investigation found that several factors could influence the usage of virtual technology such as cost, trialability, awareness, maintenance and support, and backup and restore. An interpretive approach has been employed for data collection and analysis. The study suggested a framework for adopting virtual technology at JHIEs. The proposed framework has been validated by experts in the information technology field. The framework could be used by higher education institutions in developing countries as a blueprint for better adoption of virtual machines and multilabel operating systems. However, further research is still required to improve the adoption of innovative technology at HEIs in developing countries.

Acknowledgments

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