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# THE CASE FOR UBUNTU: LINUX OPERATING SYSTEM PERFORMANCE AND USABILITY FOR USE IN HIGHER EDUCATION IN A VIRTUALIZED ENVIRONMENT

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## ABSTRACT

The use of Linux based Operating Systems (OS) in the classroom is increasing, but there is little research to address usability differences between Windows and Linux based OSs. Moreover, studies related to the ability for students to navigate effectively between Ubuntu 14.04 Long Term Support (LTS) and Windows 8 OSs are scant. This research aims to bridge the gap between modern Linux and Windows OSs, as the former represents a viable alternative to eliminate licensing costs for educational institutions. Preliminary findings, based on the analysis of the System Usability Scale results from a sample of 14 students, demonstrated that Ubuntu users did not require technical support to use the system, while the majority found little inconsistency in the system and regarded it as well integrated.

## Keywords

Usability; Linux; Computers; Information Systems; Performance; Human Computer Interaction; UX; Ubuntu; SUS

## INTRODUCTION

Presently, adoption of Linux in the personal computers market is limited when compared to the Microsoft Windows OS. For example, a recent study found that Linux held only 1% of the market share, while Microsoft Windows retained 87% (Net Market Share, 2011). When it comes down to ownership of OS, a client has two options: to buy proprietary OS, such as those offered by Microsoft, or to use open source OS free of charge (Boitor and Bratucu, 2011). Microsoft Windows is a proprietary software, which means it is closed, available at a cost, and its copyright is owned by the developers (Haider and Koronios, 2008). As a result, the source code is not available to the end user and changes cannot be made. In contrast, open source systems (OSS) allow end users access to the source code and customizing privileges for their personal use.

Considering the access to the source code as a major advantage (O'Hara and Kay, 2003), it is puzzling that Linux market share is still limited. This confusion is further compounded since a number of studies demonstrate that adoption of open source software yields reduction in costs and ease of customization (Li et al., 2011; Ven et al., 2008). Moreover, Linux has been found to be superior in customizability, security and even reliability (Ebert, 2008).

Prior research has examined the motivations of users to adopt OSS (Gallego et Al., 2008), adoption of OSS by organizations (Macredie and Mijinyawam 2011) and resistance of users (Kim et al., 2014). Areas that still remain unexplored include integration of system functionality and need for technical support. As a result, a key research question that demands an answer is: how is Linux OS perceived by users in terms of usability, integration of functionality and need for technical support in educational institutions when compared to Windows OS?

To address this question, we leverage the System Usability Survey (SUS) to examine these factors among users of Ubuntu 14.04 LTS and Windows 8.1 OS. The limited preliminary findings suggest that further research into the proposed factors is necessary to help determine lack of adoption of Linux into educational institutions.

The rest of this study is structured as follows. First, identification of key components of the OS are outlined. Next, a brief review of the instrument used for the study and preliminary results are provided. The study concludes with recommendations for future research.

## **OPERATING SYSTEM**

An Operating System (OS) is defined as a program that acts as an intermediary between a user of a computer and the computer hardware (Silberschatz and Galvin, 1994). It is a software component that is responsible for the coordination of activities and sharing of computer resources. An OS is a collection of system programs, tools and utilities that manage computer hardware and offer general services for client application software (Bassil, 2012). The operating system is the first program to do several tasks while focusing on the current task at hand. The first task is prompting the OS to boot the computer. Within minutes, the computer will manage tests to make sure everything is working properly, check for new hardware updates and then start the operating system. Once the OS is working, its main focus is to handle the specifics and writing capabilities. The operating system will coordinate with each computer's central processing unit (CPU), memory and storage to make sure that every program functions properly. An OS runs user application programs and provides a suitable interface to communicate with the computers' hardware (Bassil, 2012).

The main purpose of an OS is to provide management of computer resources and control data flow. These resources include but are not limited to memory, processors, input and output devices and abiding storage devices. The concept provided for the operating system is usually in sets providing access. Technologist uses their concepts when writing codes that are needed to obtain the operating system.

## **Technical Support**

Technical support is defined as the need for help provided by knowledgeable individuals to users of computer hardware and software products (Wilson, 1991). In this study, technical support is regarded as coaching and consultation for the installation of OS on a virtual environment. Moreover, lack of need for technical support can be regarded as a positive factor toward cost reduction and ease of use.

Virtualization is referred to as the use of virtualization software that allows physical hardware of a single PC to run numerous operating systems simultaneously on virtual machines (VM). A VM is a fully protected and isolated copy of the underlying physical machine's hardware (Sugerman et al., 2001). In essence, each user is given the impression of having a decent physical computer. This study argued that lack of need for technical support during the installation of the system. Figure 1 provides a screenshot of Ubuntu 14.04 LTS running on a VM on the Windows 8.1 desktop.

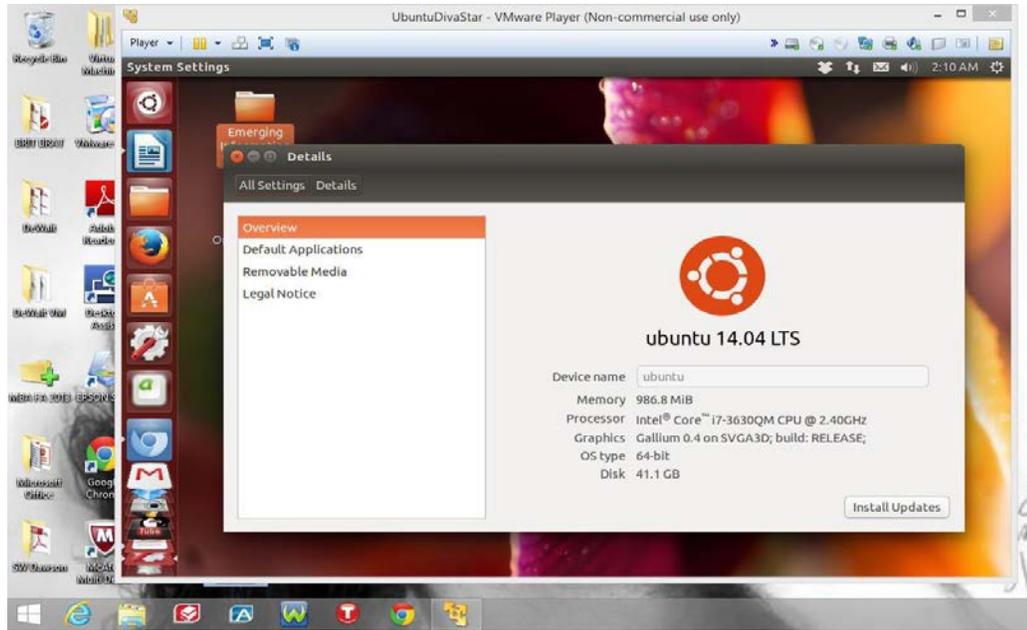


Figure 1: Screenshot of Ubuntu 14.04 VMware VM Running on Windows 8.1 Desktop.

**Performance**

The significance of the term “performance” is the speed in which a computer operates during a benchmark test. The test utilizes several working styles that imitate the work the computer should be doing. A majority of the software specifications has two types of system requirements: minimum or recommended. In addition, the demand for higher processor power and resources are included in the newer system requirements. Ubuntu 14.10 LTS and Windows 8.1 need certain hardware components and these prerequisites are known as system requirements.

The system requirements vary among Ubuntu products. The minimum system requirements for Ubuntu 14.04 LTS supports Integrated Electronics (Intel) and an Advanced Micro Devices (AMD) processors based on computers that run Microsoft Windows and Apple Macintosh systems (“Ubuntu 14.04 (Trusty Tahr) Daily Build”). Table 1 lists hardware specifications that the computer should meet as a minimum requirement. Depending on the computer needs, there are other Ubuntu distributions such as Lubuntu and Xubuntu for less processor power.

Processor	1 gigahertz (GHz) x 86 processor (Pentium 4 or better)
RAM	1 gigabyte (GB)
Hard Disk Space	5 gigabyte (GB) (15 GB is recommended)
Video Support Capable	1024×768 resolution

Table 1. Ubuntu 14.04 LTS Minimum System Requirements

In contrast, Windows 8.1 is a personal operating system that is geared toward Intel-based PC architectures. The minimum system requirements for Windows 8.1 are higher than Windows 7. The CPU supports the Physical Address Extension (PAE), NX processor bit (NX) and Streaming SIMD Extensions 2 (SSE2) (System Requirements, 2014). Windows Store application requires a screen resolution of 1024×768 or higher to run. Table 2 lists the recommended hardware specifications.

Processor	1 gigahertz (GHz) or faster
RAM	1 gigabyte (GB) (32-bit) or 2 GB (64-bit)
Hard Disk Space	16 GB (32-bit) or 20 GB (64-bit)
Graphic Card	Microsoft DirectX 9 graphics device with WDDM driver

**Table 2. Windows 8.1 Minimum System Requirements**

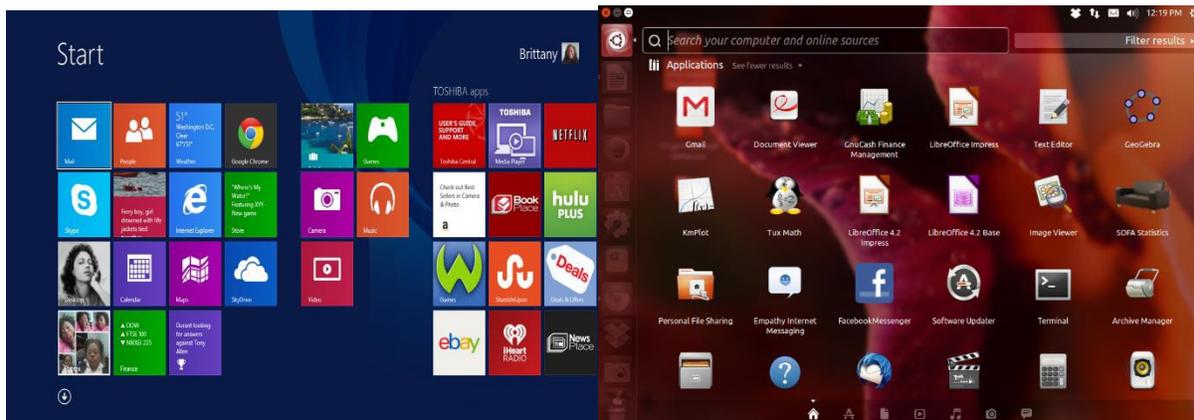
**Usability**

Usability is considered the effectiveness, efficiency and satisfaction specified when users achieve specific goals in a particular environment (Bevan, 2009). Research has proposed a number of methods to measure usability. These include product-oriented (e.g. ergonomic attributes) and user-oriented (user mental effort and attitude, user performance and user interaction) (Bevan, 2009). In this study, the usability of Ubuntu 14.04 LTS was approached from the perspective of the user-oriented approach.

**Integration**

In this study, integration of the OS was examined from the perspective of the Human User Interface (HUI) and Graphical User Interface (GUI). User interface simply means a person controls a software application or hardware device at their own disposal. The human interface guidelines (HIG) are software documents that are developed with application recommendations. Their role is to improve the user experience by devising interface applications that are more creative, learnable and consistent.

The GUI for both OSs is unique in their own way. Windows 8.1 gives users a similar graphical user interface like Ubuntu 14.04 LTS. For years, Windows has tried to change, cut-down and get rid of their versions of its operating systems and standard Windows desktop interface. They have completely changed their interfaces with pop-up windows, scroll bars, buttons and tiny Start buttons just to make them different from the next competitor in their market. Previous Windows graphical user interfaces had four or more applications on one single screen at one time, but not anymore. Windows 8 eliminates all of that and introduces touch-based text labels and controls. The interface for all of these applications are sparse. For example, email, calendar and address book are now present on the screen. There is no need to go to the menu button and scroll up or down for it. Windows 8.1 has presented a new way to any application easier than previous Windows operating systems. Figure 1 displays the differences in both graphical user interfaces for each operating systems.



**Figure 2: Displays Graphical User Interfaces for both operating systems**

## RESEARCH METHODOLOGY

### Target Population and Data Size

The target population for this study consisted of 14 undergraduate and graduate students from two intermediate information systems course at a Midwestern university. Each participant was familiar with the use of either OS. Participant ages ranged from 18-30 years old.

### System Usability Scale (SUS)

To determine usability, integration and need for technical support, this study used the System Usability Scale (SUS). SUS was originally created in 1986 by John Brooke (System Usability Scale, 2014). The scale has been used to evaluate a wide range of products and services, including software, mobile devices, hardware, websites and applications. The reliability of SUS has been demonstrated with smaller sample sizes (Bangor et al., 2009).

In this study, the participants were asked the following 10 questions adopted from the SUS, with responses ranging from Strongly Agree to Strongly Disagree on a 5-point Likert scale:

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

To interpret the results, participant's scores for each question were converted to a new number, added together, and then multiplied by 2.5 to convert the original scores of 0-40 to 0-100 (Sauro and Lewis, 2011). The scores were considered in terms of percentile ranking. A SUS score above a 68 was considered above average, while anything below 68 was regarded as below average. Scores were normalized to produce a percentile ranking.

## PRELIMINARY FINDINGS

While Ubuntu 14.04 LTS is not difficult to learn, it is different from traditional operating systems. Ubuntu's interface has been developed with features that make it easily adoptable by Window's users (Noyes, 2011). While both interfaces appear different, certain GUI features remain similar. This study found that the majority of users (44%) considered Ubuntu not complex. In terms of difficulty to use, the results showed that while nearly a quarter (22%) found the system not easy to use, over half (56%) were undecided. It can be argued that Ubuntu's interface lacks complexity.

The most important findings of this study were that 78% of the participants strongly disagreed with the statement that they would need the support of a technical person to be able to use the system. Moreover, no respondents disagreed in their perception that the various functions of the system were well integrated. Over half of the respondents (55%) reported that they felt very confident with using the system and didn't need to learn a lot of things to get going with the system. Finally, the majority of the respondents (77%) disagreed with the statement that there was too much inconsistency in the Ubuntu system.

A limitation of this study is the sample, as it is possible that the results are skewed due to the potential presence of power users. In a future study, the researchers will replicate the study using random larger sample and include structured interviews to improve reliability of the results.

## CONCLUSION

This research attempted to answer the following research question: how is Linux OS perceived by users in terms of usability, integration of functionality and need for technical support in educational institutions when compared to Windows OS? For this purpose, several factors from the OS were examined (mainly performance, usability, integration and technical support) and the SUS instrument was used to observe users' perceptions of the Linux OS Ubuntu. While the preliminary findings demonstrate that Ubuntu users do not require technical support and perceive the system as well integrated and not inconsistent, the study is limited. Future studies should attempt to examine the factors through the prism of different instruments and with a greater number of subjects.

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