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Transfer of Ncomputing Technology in Education Sectors – The Economy Context

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ABSTRACT

In the recent years Ncomputing Technology has proved to be one of the key costs saving approach in educational sectors. This attracts some interests of analyzing to which extent these devices bring cost relief to the users and stakeholders who deploy Ncomputing in secondary schools. This research performs analysis by comparing the deployment costs of desktop computers with the costs to deploy Ncomputing in the Computer Labs. This research also explores the cost implications for deploying each of the Ncomputing devices while comparing with the cost of deploying desktop computers. The analyisis goes further by observing the economic impact of each of the Ncomputing devices and explore their relationships in terms of costs when compared to the desktop computers' implementation. The findings show that, generally, Ncomputing has a significant cost relief by more than 53% when deployed on a single Computer Lab of 40 students when compared to deploying desktop computers. Furthermore, Ncomputing M300 seem to be the cheapest option with up to 74% cost saving while the least option found to be U170. In this paper, recommendations from the key vendors and opinions of local users of Ncomputing are also presented. Finally, we have discussed several factors that limits Ncomputing adoption in secondary schools.

KEYWORDS

Ncomputing, Education Sectors, Ncomputing devices, Desktop Computers, Ncomputing Technology and Computer Lab.

1 INTRODUCTION

Ncomputing Technology has emerged to be a significant option in cost-benefit aspect in different sectors. Several studies indicated that there is a considerable cost saving which occurs once these devices are used instead of using traditional PCs. Technically, this is due to the fact that it allows sharing of Desktop computers through Desktop Visualization allowing few computing resources to be shared among the same room or purpose. This research targets secondary schools in Tanzania. It then compares the costs associated by the use of PCs in the class rooms and compares it with several Ncomputing devices. The aim is to explore the cost implications of each of the popular NComputing devices relative to the PCs. That means, the cost of PCs is taken as a benchmark for this experiment-based research.

To compare the costs incurred when using PCs or Ncomputing in Tanzania, we need to set a unit on which the comparison will base on. In this study, we will base our comparison on a single computer lab in a secondary school. The optimum size of a computer lab is that which takes a single class with one computer per student, which means the number of computers (or workstations) to be equal to the size of the class (i.e. number of students in that classroom). Since there are variations in class sizes in secondary schools throughout the country, then we will rely on a standard

secondary school class size (norm) of 40 students [1] to represent the size of our computer lab in a secondary school.

In this study, only computer and accessories hardware costs will be considered and not all aspects of total cost of ownership, which is complex to calculate. In addition, minitower computers will be favored due to their flexibility in upgrading. The pricing of the computers and other accessories is according to Government Procurement Services Agency (GPSA), which is responsible for procurements of common use items for all government offices, except for the Ncomputing devices prices, which were obtained from the Ncomputing supplier, Soft-Tech Consultants. Non-government schools are not bound to use GPSA, which means that if they go for direct shopping the prices will be a little lower than those in GPSA contracts. Since the Ncomputing devices from the supplier were in dollars (US $), the BOT exchange rate of US $ 1 to TZS 1636 of 17/04/2014 was used to change all prices to Tanzanian shillings. The rest of this paper is organized as follows; Section 2 presents a literature review on the Ncomputing technology and some of the similar researches are also presented. In the section 2, we have also reviewed the Ncomputing adoption status in Tanzania. Section 3 show results and some discussions are shown. Section 4 presents a critical analysis on the results and observations while observing the opinions of the users of Ncomputing tecnnology and finally section 5 is a conclusion for this research article.

2 LITERATURE REVIEW

2.1 Ncomputing Technology

NComputing utilises a computer technology called ‘desktop virtualisation’, where the resources of one machine are spread to several users. [2], in their white paper, claim that many of the concepts behind the NComputing solution are similar to the traditional thin client model; however, NComputing has developed a completely unique implementation that delivers better performance at a lower cost.

The approach of NComputing is similar to thin client, but the difference is that the Access Terminals are much smaller and more integrated than traditional thin clients. In this case, not only servers can be shared, but standard PCs can be shared as well. The end-users will have their own monitor, keyboard, mouse and speakers connected to the small NComputing access terminals on their desk. The access terminals then connect either directly (X and U Series) or over Ethernet (M, L and N Series) to the host computer or server which runs the NComputing terminal services software, called vSpace.

The NComputing solution has three components:

- Access devices that connect the user’s monitor/peripherals to the host computer
- Virtualisation software (vSpace), which virtualizes the host computer to create multiple sessions
- User eXtension Protocol (UXP), which transmits the data and video signals between the user and the host computer.

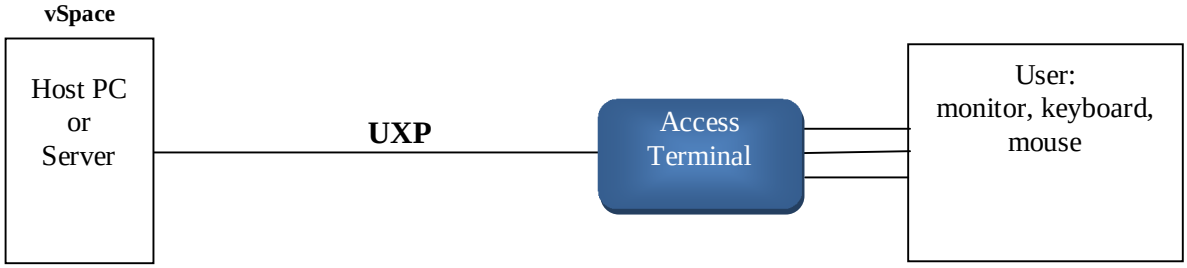

Figure 1: Users are connected to the Host through the access terminals [3]

Ncomputing has produced popular five (5) types of access devices. There are the U-Series, X-series, M-series, L-Series, and the N-series (NComputing, 2010c, 2013a). The U-series virtual desktop access terminal can support a maximum of ten (10) users; the X-Series can support a maximum of eleven (11) users per PC, the M-series kit includes three access terminals (3-in-1) allowing 45 users to share the resources of one PC or server, the L-Series devices allow up to 100 users to share one PC or server, and the N-series devices are purpose-built for organizations deploying the Citrix VDI-in-a-Box solution and provide 100% of the benefits of the Citrix HDX experience [4].

2.2 Previous Researches

Only few researches have been conducted to analyze comparison analysis in Desktop virtualization technology. A notable research is the one which was conducted by Nieh J. *et al.* (2000) to analyze several Thin Client architectures by analyzing different performance metrics at several bandwidth levels. Also, Yang *et al.* (2002) conducted an experiment to assess the capability of Thin Client computing model by measuring the performance of six different platforms running on a range of network bandwidths. Finally, Michael, R *et al* (2012) analyzed the performance for thin client platforms under different bandwidth levels and came up with findings of performance behavior by using previous data as references.

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2.3 Ncomputing Adoption in Tanzania

Despite of the notable advantages of Ncomputing, still many developing countries, including Tanzania, have not yet succeeded to provide sufficient computers in their schools to improve access, partly due to financial constraints and infrastructural issues. The number of computers in secondary schools in Tanzania is very low, where the average national computer-to-students ratio in secondary schools is 1:200 [1]. Most of the secondary schools being in rural areas are not connected to the national grid. Only 1,107 (24%) secondary schools in Tanzania mainland are connected to the national electricity grid [1]. There are no sufficient skilled IT professional in Tanzanian secondary schools, which is also addressed in the ICT Policy for Basic Education [16].

The above mentioned weaknesses hinder proper use of ICT in the teaching and learning in the secondary schools. This scarcity of ICT resources in schools has resulted into teaching ICT theoretically without students having a touch of the facilities to practice and explore, and to practice the student-centered learning approach. The advocated use of ICT as a teaching and learning tool has been difficult to be realized as there are no sufficient ICT tools (e.g. computers) to use.

3 RESULTS AND DISCUSSIONS

3.1 Costs of purchasing PCs in the computer lab

There are several computer brands available in the market but the most common ones in Tanzania are HP and DELL. Hence in this study, the analysis will confine on HP and DELL computers, and to maximize flexibility and room for upgrading, we will select minitower computer form factors. According to GPSA framework contracts costs for the financial year 2013/2014 [9], the minimum price for the PC meeting our case is TZS 1,875,400 with Intel core i3 processor and 2GB RAM (DELL Optiplex 310 MT).

Table 1: Hardware costs of a 40-seat Computer lab with PCs throughout

Item	Unit cost (TZS)	No: of of unit	Total cost (TZS)
PC	1,875,400	40	75,016,000
UPS (APC 750VA)	622,600	40	24,904,000
Total	**2,498,000**		**99,920,000**

Therefore, for a computer lab of 40 seats a minimum of TZS 99,920,000 will be used, with cost per seat (workstation) of TZS 2,498,000.

3.2 Costs of purchasing Ncomputing devices in the computer lab

There are several Ncomputing series available to use. These are the U-Series, X-series, M-series, L-Series, and the N-series [5],[4]. From these series we will test the costing of each device except the following:

N-series (needs access to a Citrix environment to work) [7], X300 (not available, as per supplier data), L130 and L230 (works in a LAN environment, needing only one host, but have a maximum of 30 users per host [6], not fit for our class of 40 seats). Hence, the devices to be costed are U170, X350, X550, M300, and L300. Throughout the estimations we will assume a Linux distribution (e.g. Ubuntu) as our operating system, such that no operating system licence costs will be incurred.

Table 2: Hardware costs of a 40-seat computer lab with Ncomputing U170 devices

Item	Unit cost (TZS)	No: of units	Total cost (TZS)
PC	1,875,400	14	26,255,600
UPS (APC 750VA)	622,600	14	8,716,400
U170	179,960	26	4,678,960
Monitor (17")	240,900	26	6,263,400
Keyboard	40,400	26	1,050,400
Mouse	15,300	26	397,800
Total			**47,362,560**

3.2.1 A computer lab setting with U170

This virtual desktop access terminal utilises the included USB cable to connect to theshared host computer. Access terminals may be connected directly to the PC's USB ports or through a USB hub. A maximum of ten (10) users can simultaneously share a single PC [8].

The actual number of users to share a single host depends mainly on the host's configuration (technical specifications). To simplify the costs estimations, we will always select the host computers that are as close as possible to the normal PCs available for purchasing at school level.

From the above reason, we will select our host computers as the ones used in section 3.1; i.e. Intel core i3 with 2GB RAM. With this computer, considering recommended settings from the manufacturer of the devices, up to 3 users can be connected on a single host [8], which makes a need for 14 hosts (PCs) to make 40 seats in our standard computer lab, where only 26 devices will be needed to make a total of 40 seats (14 + 26).

Then, for a computer lab of 40 seats an estimate of TZS 47,362,560 will be used, with an average cost per seat of TZS 1,184,064. This cost indicates a total cost saving of 53% percentage as compared to using PCs alone.

3.2.2 A computer lab setting with X350

Table 3: Hardware costs of a 40-seat computer lab with Ncomputing X350 devices

Item	Unit cost (TZS)	No:of units	Total cost (TZS)
PC	1,875,400	10	18,754,000
UPS (APC 750VA)	622,600	10	6,226,000
X350 kits	335,380	10	3,353,800
Monitor (17")	240,900	30	7,227,000
Keyboard	40,400	30	1,212,000
Mouse	15,300	30	459,000
5m Cat 6 cables	8,200	30	246,000
Total			**37,477,800**

The X350 uses a PCI card which installs in the
PC. The PCI card has three RJ-45 ports that connect to the X350 access terminal through a direct Cat 5 or Cat 6 cable (up to 10m in length) (sold separately), where a maximum of seven (7) users can simultaneously share a single PC [10]. The X350 desktop virtualization kit includes a license for NComputing vSpace software, one low-profile X350 PCI card, and three (3) XD2 access devices.

As above, the actual number of users to share a single host depends mainly on the host's configuration (technical specifications). Using our normal PCs as discussed in 3.1 (Intel core i3, 2GB RAM), and considering recommended settings from the manufacturer of the devices, a single host can be connected to a single kit (3 devices, making 4 users) [10], which will then require 10 hosts (PCs) to make 40 seats in our standard computer lab, where only 10 kits (30

Table 4: Hardware costs of a 40-seat computer lab with Ncomputing X550 devices

Item	Unit cost (TZS)	No: of units	Total cost (TZS)
PC	1,875,400	7	13,127,800
2GB RAM	32,800	7	229,600
UPS (APC 750VA)	622,600	7	4,358,200
X550 kits	497,344	7	3,481,408
Monitor (17")	240,900	33	7,949,700
Keyboard	40,400	33	1,333,200
Mouse	15,300	33	504,900
5m Cat 6 cables	8,200	33	270,600
Total			**31,255,408**

Table 3 indicates that, for a computer lab of 40 seats an estimate of TZS 37,477,800 will be used, with an average cost per seat of TZS 936,945. This cost indicates a total cost saving of 62% percentage as compared to using PCs throughout.

3.2.3 A computer lab setting with X550

The X550, like X350, uses a PCI card which installs in the PC. The PCI card has five RJ-45 ports that connect to the X550 access terminal through a direct Cat 5 or Cat 6 cable (up to 10m in length) (sold separately), where a maximum of eleven (11) users can simultaneously share a single PC [10]. The X550 desktop virtualization kit includes a license for NComputing vSpace software, one full-height X550 PCI card, and five (5) XD2 access devices.

As above, the actual number of users to share a single host depends on the host's configuration (technical specifications). Considering recommended settings from the manufacturer of the devices, the minimum required host for this type of device is a bit of higher specifications than our normal PCs as discussed in 3.1 (Intel core i3, 2GB RAM). It requires a 3.0GHZ processor with at least 3GB RAM computer [10]. The above computer from GPSA contracts meets the 3.0 GHZ processor speed (Intel core i3-3220) (Intel, 2014), but we need to add another RAM to improve its specification to around 4GB. This will require buying a 2GB of RAM. With this setting a single host can be connected to a single kit of X550 (5 devices, making 6 users per host) [10], which will then require 7 hosts (PCs) to make 40 seats in our standard computer lab, where only 7 kits (35 devices) will be needed to make a total of 42 seats (7 + 35) possible.

Then, for a computer lab of 40 seats an estimate of TZS 31,255,408 will be needed, with an average cost per seat of TZS 781,385. This cost indicates a total cost saving of 69% percentage as compared to using PCs throughout.

3.2.4 A computer lab setting with M300

The M300 device, unlike the previous devices discussed, uses Ethernet to connect to the host (PC) in a network environment. A maximum of 45 users can simultaneously share a single PC. Each M-series kit includes three access clients;

a central large client connected via Ethernet to the existing LAN, and two small clients which connect to the large client. Each of the three clients affords their users an independent desktop experience [11].

Table 5: Hardware costs of a 40-seat computer lab with Ncomputing M300 devices

Item	Unit cost (TZS)	No: of units	Total cost (TZS)
PC (host)	2,621,200	1	2,621,200
4GB RAM	59,400	3	178,200
UPS (APC 750VA)	622,600	1	622,600
M300 kits	613,500	14	8,589,000
Monitor (17")	240,900	40	9,636,000
Keyboard	40,400	40	1,616,000
Mouse	15,300	40	612,000
5m Cat 6 drop cables	8,200	40	328,000
48 ports Network Switch	382,600	1	382,600
Network cable rolls (cat 6)	183,600	2	367,200
LAN cabling and other materials	1,000,000	1	1,000,000
Total			**25,952,800**

The host's configuration (specifications) required to provide an optimal user experience will vary with the number of users. The minimum required host for this type of device, as per recommended settings from the manufacturer, is a computer with an Intel core 2 quad processor, and 4GB RAM (32 bit OS), which will allow up to 10 users per computer [11]. This is not suitable for this configuration as it will need 4 hosts to make our 40 seats lab, which will result into a complicated LAN environment, with 4 hosts connected on a single switch. Another alternative is to create 4 different LANs, each with a single switch and host, in a single computer lab, which will be impractical. So, the simplest way is to create a single LAN with a single host and switch, but the configurations of the host must be able to support 40 simultaneous users.

From the manufacturer's recommended settings, we will need Intel core i7 processor, 16GB RAM and a 64-bit OS to have the number of users between 30 and 45 [11]. From GPSA Contracts 2013/2014, the minimum price for this computer is TZS 2,621,200.00 (DELL Optiplex 7010MT, 4GB RAM). We will have to buy extra RAM (12GB) separately. With this setting a single host can be connected to fourteen (14) kits of M300 (14x3 devices) giving 42 possible seats (in this LAN environment the host is treated as a server and not included in the classroom seats).

Table 5 indicates that, for a computer lab of 40 seats an estimate of TZS 25,952,800 will be needed, with an average cost per seat of TZS 648,820. This cost indicates a total cost saving of 74% percentage as compared to using PCs throughout.

3.2.5 A computer lab setting with L300

The L Series products connect to the host PC or server through a standard network connection. All the access terminals connect to a network switch on which the host PC or server is also connected. With the L300 access terminal, a maximum of 100 users can simultaneously share a single PC (The number of users that an installation will support depends upon the host's configuration and end-users' performance expectations). An L300 kit includes only one L300 device.

Table 6: Hardware costs of a 40-seat computer lab with Ncomputing L300 devices

Item	Unit cost (TZS)	No: of units	Total cost (TZS)
PC (host)	2,621,200	1	2,621,200
4GB RAM	59,400	3	178,200
UPS (APC 750VA)	622,600	1	622,600
L300 kits	322,292	40	12,891,680
Monitor (17")	240,900	40	9,636,000
Keyboard	40,400	40	1,616,000
Mouse	15,300	40	612,000
5m Cat 6 drop cables	8,200	40	328,000
48 ports Network Switch	382,600	1	382,600
Network cable rolls (cat 6)	183,600	2	367,200
LAN cabling and other materials	1,000,000	1	1,000,000
Total			**30,255,480**

For the size of our computer lab (40 seats), the minimum required host for L300 device, as per recommended settings from the manufacturer, is a computer with an Intel core i7 processor, 16GB RAM and a 64-bit OS to have the number of users between 30 and 50 [12]. From GPSA Contracts 2013/2014, the minimum price for this computer is TZS 2,621,200.00 DELL Optiplex 7010MT, 4GB RAM). We will have to buy extra RAM (12GB) separately as for M300. With this setting a single host can be connected to forty (40) kits of L300 (in this LAN environment the host is treated as a server and not included in the classroom seats).

Then, for a computer lab of 40 seats an estimate of TZS 30,255,480 will be used, with an average cost per seat of TZS 756,387. This cost indicates a total cost saving of 70% percentage as compared to using PCs throughout.

3.3 Ncomputing Cost Comparison Analysis

All Ncomputing devices show a big saving of costs when used in a computer lab in place of PCs. The table below (table 7) summarizes the estimated cost savings (in TZS) for a school computer lab of 40 users

Table 7: Summary of Ncomputing hardware cost savings

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System used in lab	Total hardware costs	Percentage cost saving compared to PCs	Average cost per seat
PCs	99,920,000	-	2,498,000
U170	47,362,560	53%	1,184,064
X350	37,477,800	62%	936,945
X550	31,255,408	69%	781,385
M300	25,952,800	74%	648,820
L300	30,255,480	70%	756,387

From table 7, a computer lab setting using M300 Ncomputing devices is the lowest in terms of hardware costs (74% cost saving) followed by L300 (70% cost saving). This can be viewed well in Figure 2.

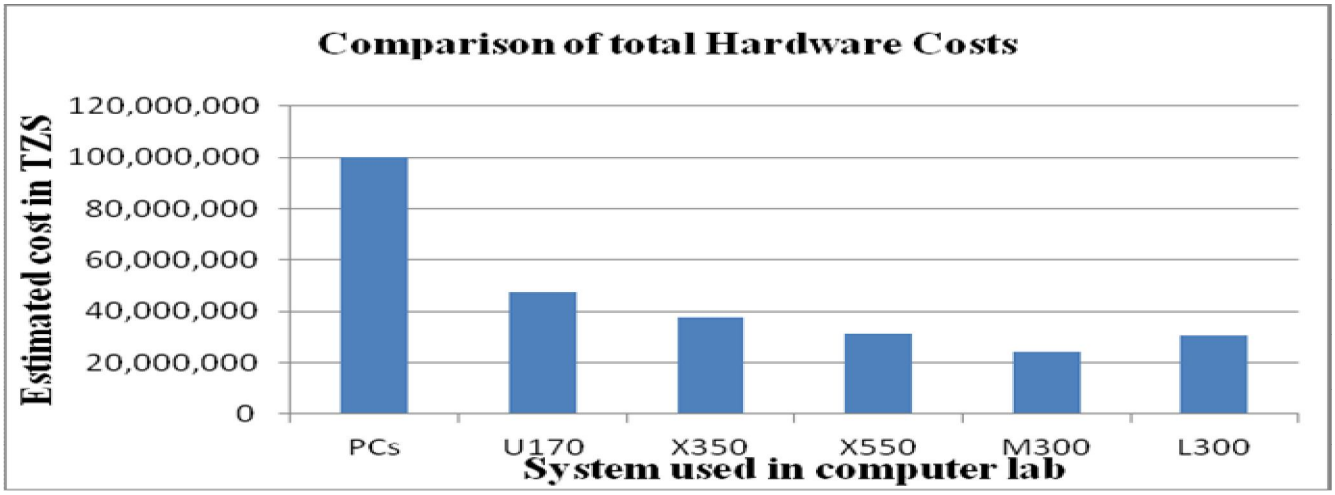

Figure 2: Comparison of Hardware Costs of PCs and Ncomputing Lab use

3.4 Ncomputing Choice for Secondary Schools in Tanzania

Respondents from this study were given opportunity to suggest the best Ncomputing solution for secondary schools using their knowledge, experiences and brief information given on the number of users to be supported by a single host and the host's recommended configuration. The results of their choices are as summarised in Table 8.

Table 8: Choice of Ncomputing devices

Ncomputing model selected	Number of respondents	Percentage
L300	29	69%
M300	12	29%
L130	1	2%
Total	42	100%

Most of the respondents recommended L300 (69%), followed by M300 (29%) as seen in Table 8. The only reason given by all respondents selecting the Ncomputing L300 devices is the ability of taking large number of students at once when these devices are used. Those selected Ncomputing M300 had a main reason that this will help to host a standard single class in our schools. All the respondents didn't consider other factors like cost, deployment, and management of the class. On the other side, the Ncomputing supplier (Soft-Tech consultants) suggested X550 and L300 as best for Tanzanian secondary schools.

4 CRITICAL ANALYSIS

This research exposes a lot of decision issues regarding cost-benefit analysis in deploying Ncomputing devices. Yes, it is with no doubt that it favours simplicity in terms of installation and usability and it has, in general, a significant cost implications. This research goes further by suggesting the best Ncomputing option for effective cost conscious decision by secondary schools although the decision makers who are in place have their criterions for selecting the best devices to use based on their personal interests which seem to rely on the usability issues. That means, there is a compromise on the trade off between cost and usability issues which have to seriously be addressed. The findings of this research therefore try to only guide the stakeholders on the cost implications once there is a project of deploying Ncomputing devices.

4.1 Limiting factors of Ncomputing Adoption

Lack of awareness is the most limiting factor for schools not implementing Ncomputing, as it can be seen from figure 3, 59% claims that it is a new technology to them. Reasons given for Ncomputing not being common in secondary schools in Tanzania all can be interpreted as not knowing the existence of this technology and its benefits to most of the schools and managing authorities. For example, reasons like Ncomputing being expensive and lack of funds shows that it is not known by the schools and authorities that Ncomputing saves a considerable cost as compared to PCs.

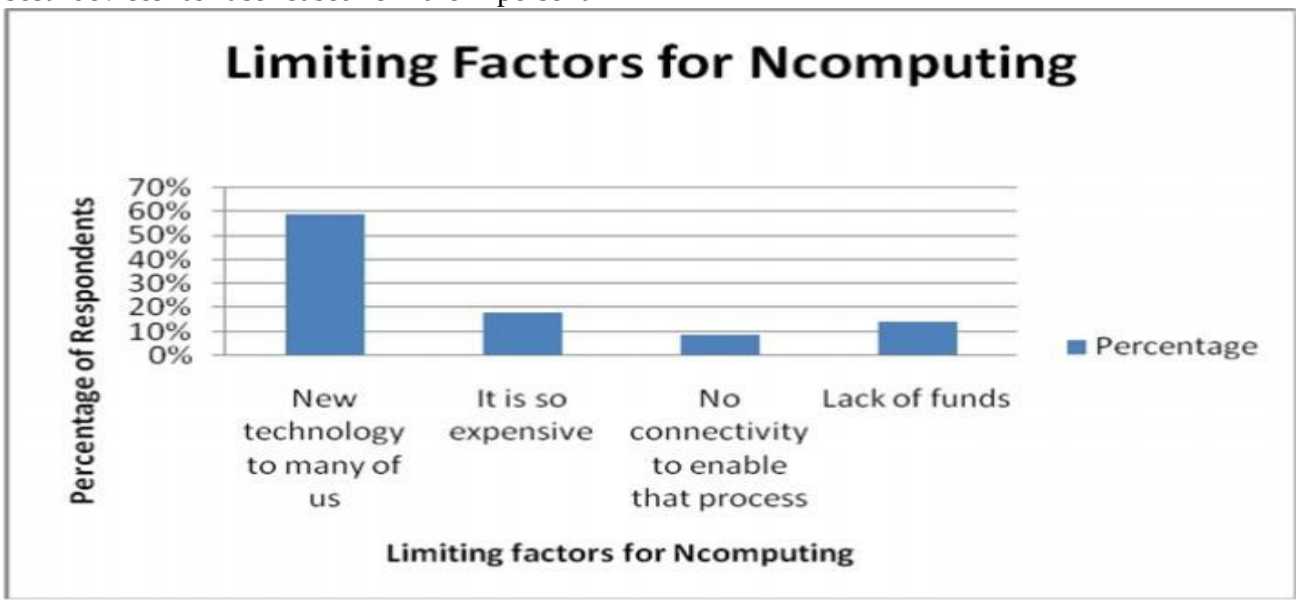

Figure 3. Reasons for not opting Ncomputing in Secondary Schools in Tanzania

5 CONCLUSIONS

This research paper discusses the cost implications in adopting Ncomputing technology. It targets Tanzania Education Sector by involving different stakeholders of secondary schools. The benchmark used was the cost of deploying desktop computers in a lab of 40 students. This cost was then compared by the costs of implementing different types of Ncomputing devices on the same room size. The result shows that M300 device are much better in terms of cost by saving 74% of the cost while the worst option is the use of U170 which saves only 53% of the cost when compared to deploying desktop computers in the same room. This research also reveals that the traditional approach in adopting these Ncomputing devices do not rely on cost rather they depend on the interests of the decision maker which falls to the usability issues. The analysis also shows that the key factor which affects the adoption of Ncomputing in Tanzania perspective is awareness of such technology.

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