Desktop Virtualization: Applications And Considerations

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ABSTRACT

As educational technology continues to rapidly become a vital part of a school district's infrastructure, desktop virtualization promises to provide cost-effective and education-enhancing solutions to school-based computer technology problems in school systems locally and abroad. This article outlines the history of and basic concepts behind desktop virtualization and discusses obstacles to implementation and benefits that result from its use in educational settings. A large school district in Maryland was used as an entry point to illustrate the potential gains of utilizing desktop virtualization technology. Through use of Bolman and Deal's (2008) approach to reframing organizations for change, this article aims to explain what implementation of virtualization technology would require in an applied setting and clarify how all parties in the school-based educational arena will benefit from this technology over time. It was concluded that those entrusted with executive decision-making power in America's school systems would be wise to consider employing virtualization technology in their classrooms.

Keywords: Desktop Virtualization; Educational Technology; School Systems; Reframing Organizations

INTRODUCTION

Over the past 25 years, personal computers have moved from being rarely used in educational settings to being integral agents of change in classrooms across the world. While this change has been dramatic, often school administrators and educators expect more from computer technology than they receive. Many administrators have become increasingly frustrated with school computing issues relative to energy costs, IT expenses, PC replacement expenditures, data storage capacity, and security while teachers have expressed concern with computer technology as it relates to accessibility, software attainment and updates, computer performance, student performance, lesson supplementation, personalized classroom instruction, and student ownership (The Greaves Group, 2007, pp. 8-13). As technology continues to rapidly become a vital part of a school district's infrastructure, desktop virtualization, in particular, promises to provide cost-effective and education-enhancing solutions to school-based computer technology problems in school systems throughout the world.

OVERVIEW

Although not a new concept, virtualization has more recently (within the last 5-10 years) been manipulated and employed by school districts in ways that reduce bottom line costs and provide academic benefits for students, teachers, and administrators alike. Directly put, desktop virtualization refers to a concept where access to a single piece of hardware, like a server, is coordinated so that multiple computers (called "thin clients") can share that single piece of hardware without end users (or computer users) being aware that they are actually sharing anything at all (Golden, 2008, p. 10). Thus, a virtualized desktop system provides end users with remote access to the desktop environment through "thin client" devices which are essentially gutted PC's that are wired to function in a virtualized system. Through this centralized, server-based infrastructure, end users are able to access what they would typically see on a PC (e.g. applications such MSWord or PowerPoint) in a familiar way (with a user id and password) from any computer within the system regardless of geographic location or physical packaging of the user's device. It is then possible to run programs from different operating systems (Microsoft Windows, Mac OS, Linux, etc.) at the same time on the same hardware.

Virtualized desktop technology provides solutions to the many school-based computing problems referenced in this introduction. This article will illustrate why those entrusted with executive decision-making power in United States school systems, such as Prince George's County, Maryland, would be wise to consider virtualized technology in their classrooms and computer labs. It will also explain what implementation of this technology would require and look like in an applied setting and clarify how all parties in the school-based educational arena will benefit from this technology over time. Strong testimonials from teachers, students, and administrators across the nation, in addition to evidence resulting from data analysis from schools with implemented virtualized systems, reinforce the fact that desktop virtualization undoubtedly increases school operational efficiency and enhances teacher instruction and student learning across the board.

CRITICAL ISSUES AND SUPPORTING RESEARCH

It is important to specifically discuss the benefits of desktop virtualization in relation to the categories of improvement referenced in the introduction and illustrate researched evidence confirming these benefits. These categories can be divided into cost reduction and academic benefits.

First off, benefits relative to operational efficiency and related costs will be discussed and then academic benefits will be articulated. All research points to the fact that virtualization will save school districts substantial amounts of money. Generally speaking, according to Gartner Inc. (2008), a leading IT research and advisory company, virtualization will be the highest impact trend-changing infrastructure and operations going forward as virtual machines will continue to be installed on servers at a rapid pace. Universities, such as ABET Open University (2007), are offering MBA degrees in the field of computer virtualization management where candidates learn how to install, configure, run, and troubleshoot virtual machines (p. 1).

Clearly, virtualization technology is in increasingly high demand, but why? For starters, virtualization's ability to reduce the total number of physical servers will significantly reduce the overall cost of energy for schools (Golden, 2008, p. 15). The Greaves Group (2007) explains that schools can expect to save $300 to $600 in annual energy costs for each server that is removed (p. 10).

Secondly, desktop virtualization is helping schools utilize older PC's, thus reducing the cost of new student workstations. Schools do not have to discard old or even failing PC's in order to set up virtualization workstations because virtual desktop software can be installed on any PC where that existing PC will become a thin client device in the virtual system. If more thin clients are needed, they can be purchased for a fraction of the cost of what a standard desktop PC would cost. Money saved here could be reinvested in buying academic software packages or additional thin client devices.

Thirdly, total cost of ownership (TCO) is likely to decrease. A Greaves Group (2007) data analysis survey indicates that 50% of the TCO of a PC is classroom support and IT support costs (p. 8). Virtualized thin clients can lower TCO by reducing cost of operations in addition to classroom and IT support. Since software and data are managed centrally, IT provisioning (specifically the need to pay numerous IT professionals), maintenance, regulatory compliance, and backup processes are all streamlined. As a result, tasks that typically burden end users are managed by a small IT staff.

Finally, software licensing and security enhancements will reduce costs. With virtual workstations, thin clients maximize utilization of software licenses, thus you only need to purchase software licenses for the highest simultaneous usage of any given product. This means a license does not need to be purchased for each thin client device. Additionally, the virtual system is more secure since all data are located on a centralized server as opposed to numerous PC desktops throughout a school. The chance that thin clients will be stolen is remote since these devices are immediately rendered inoperable once disconnected from the virtual server. The virtual connection also protects against viruses and end user tampering by centralizing all applications and operating systems.

The academic benefits from implementing a virtual desktop system throughout a school district are distinct and well documented. Perhaps the greatest affordance of desktop virtualization is flexibility or student ownership. This means that students, or anyone for that matter, will always get a consistent virtualized PC experience no matter

which computer they use within the system. Students sign in with a user name and password at a thin client station to access the work they have done or the applications they may have opened. After signing off, all student work is saved to the centralized server, thus giving students the look and feel of having their own personal computer regardless of which thin client device they use. Students can store their data from one school year to the next without expending system resources. This geographic user freedom is even being extended to usage on cell phones, smart phones, and portable game consoles which would continue to give students ownership over their computer-based educational experiences (The Greaves Group, 2007, p.7).

Another educational affordance of desktop virtualization is classroom mobility. Many schools may house a language lab or other specialized set-up that is strictly designated for said use. With virtualized flexibility, any room with computers can become a specialized computer lab where students can interact with content-specific applications. As Jennifer Nastu (2008) explains, "…a classroom can be used for any type of class, regardless of the applications needed to teach that class" (p. 24). This allows for spatial flexibility throughout each school as teachers no longer need to scramble to secure a specific room for their computer-based lessons.

A virtual system will undoubtedly make a school's infrastructure more efficient and thus save time for teachers and students to focus on educational tasks. Such was the case with The Collier County School District of Naples, Florida. CCSD is one of the largest school districts in the country. Technologically, this district utilized 21,000 computers on 700 servers. The district technology director explained that they were "…replacing 7,000 desktops every year and had to get it all done during the two months of summer" (Dyrli, 2007, p. 1). Computer maintenance was costing much more than the district could afford. After switching to virtual clients, the school district saved a significant amount of money by cycling out many of their servers and using old PC's as thin clients in the new virtual system. The school district used the money they saved to purchase additional education materials.

Fairfax County in Virginia is the nation's 13th largest school district with 164,000 students, 236 schools, 22,000 faculty, and nearly 88,000 computers (Nastu, 2008, p. 2). After deciding to go with Microsoft Application Virtualization, the County is seeing numerous benefits. Chris Lewis, IT desktop manager for the school district, decided to go virtual because he liked the fact that virtualization would remove the need to install programs on individual computers and allow the district to avoid hardware dependencies. Since virtual capabilities have been enabled, the district has enjoyed a sharp reduction in application-related help-desk tickets, a 50% reduction in image maintenance, and a reduction in application complexity (Nastu, 2008, p. 2). Despite these economic savings he believes the real benefits are for students and staff who have application stability and enjoy "anytime, anywhere" access to applications (Nastu, 2008, p. 2). Everyone involved in the virtualization journey was satisfied with the results.

Finally, educational benefits resulting from computer-based instruction are well documented. Students learn more in less time when they receive computer-based instruction and they are more likely to develop positive attitudes and like their classes more (Schacter, 1999, p. 4). In addition, students in technology-rich environments showed increased achievement in preschool through higher education for regular and special needs children. Computer technology is also responsible for increasing students' self-concept and achievement in all major subject areas (Schacter, 1999, p. 5). Desktop virtualization makes computer-based instruction easier and more accessible to students and thus helps them gain access to tools that enhance learning across the board.

OPPOSITION AND FALLBACKS

It is pertinent to discuss reasons why desktop virtualization may not be tailored for inclusion in certain academic environments. Some have argued that it is difficult to manage a virtual system. As Anil Desai (2008) points out, "Client computer deployment and provisioning can be a time-consuming and laborious process and you often lose sleep worrying about the theft of data." (p. 1) Desktop virtualization is only as good as its implementation, so system designers must carefully maintain access rules so that sensitive data remain in the data center. Most system designers do, however, keep a cautious and watchful eye over their domain so this concern is circumstantial at best.

Some points have been made about the cost of desktop virtualization being a drawback. For example, data center hardware resources may be more expensive than their desktop counterparts, but this can be curbed by installing and coordinating among several different software products. Cost depends on the needs and existing infrastructures of potential school clients, so a good consultant and system designer would be able to help maximize cost benefits. The bottom line is that IT personnel and consultants should help decide whether desktop virtualization is right for a particular school district.

Additionally, there is an overarching intellectual argument that claims an overly virtual culture will destroy the previously held and cherished notion of culture that we have maintained for many years. As Robins and Webster (2002) explain, "Digital networks are becoming a basis for reimagining community because they now materially surround individuals and groups as environments" (p. 250). This virtualized takeover threatens to undermine traditional conceptions of culture and set the new standards for mediating economic forces, articulating political directives, and circulating social constraints as informational effects. Thus, culture is refashioned out of cyberspace and power is transmitted within it. This point is interesting and viable from a philosophical vantage point, but it should not be a deterrent to the implementation of virtual systems. The argument that print discourses, face-to-face classes, and paper documents are ominously being replaced by digital discourses and electric documents does not provide sufficient holding power in opposing virtual technologies. Print sources may or may not disappear, but the good that comes from desktop virtualization will surmount any relative cultural displacements that may result from its implementation.

ENTRY POINTS

In application and implementation, desktop virtualization promises to enhance the overall productivity and quality of a school system. One such school system that may be considered a good candidate for desktop virtualization is the Prince George's County School system in Maryland. PG County is one of largest school district in the nation. It has nearly 200 schools that educate nearly 123,000 students. The population of PG County is 871,233. The median household income is $71,260 and 85.8% of individuals over 25 are high school graduates (United States Census Bureau). These demographic numbers initially suggest that PG County can benefit from desktop virtualization in various ways. The shear immensity of the student and overall population indicates that PG County has an ample population in which desktop virtualization can thrive. The median household income is only slightly below the state average, not to the degree that it would be an economic hardship to pay for virtualization technologies with tax dollars. Further, PG County may qualify for E-Rate subsidies from the national government based on these statistics which would help fund the project.

Wesley Watts Jr., CIO of PG County, has been exploring options to implement a more cost-effective SIS (Student Information System) to keep track of student scheduling, attendance, and enrollment. Watts states, "We were one of the first K-12 districts to make use of Oracle Financials as a central part of our infrastructure, so we had some recent experience, good and bad, with large-scale IT implementation" (Hoffman, 2008, p. 1). As evidenced by this move, PG County is clearly currently interested in using technology to enhance school operations and they have a $1.4 billion annual budget to do it with. These responses and data signify that PG County school leaders will benefit from a visit by a corporate consultant from a virtual desktop industry leader such as IBM or Sun Microsystems.

Before laying out a sample action plan, it is important to discuss the four frames (human, political, structural, and symbolic) of organizational analysis, as articulated by Bolman and Deal (2008), as they relate to the key elements of a desktop virtualization project. Bolman and Deal (2008) describe the activity of reframing as "looking at the same thing from multiple lenses or points of view", and consequently, when nothing seems to be working smoothly within an organization, reframing is a "tool for gaining clarity, regaining balance, generating new options, and finding strategies that make a difference" (p. 22). Frames can be understood as mental models; they are logical sets of ideas that can be used to understand and clarify what goes on in an organization. A reframing approach can be employed to help schools understand how they can use desktop virtualization to enhance overall operations and specifically increase student performance. Bolman and Deal (2008) explain that the structural perspective "argues for putting people in the right roles and relationships" (p. 47). The structural frame is intellectually rooted in ideas of maximum efficiency and rationality. The human resource frame encompasses the

idea that organizations "exist to serve human needs" since people and organizations need each other (Bolman & Deal, 2008, p. 122). Ideally, organizations will benefit from satiating the needs of their employees and customers. From a political frame perspective, politics are at the heart of decision making. As Bolman and Deal (2008) explain, "politics is the realistic process of making decisions and allocating resources in a context of scarcity and divergent interests" (p. 190). The symbolic frame focuses on "how humans make sense of the chaotic, ambiguous world in which they live" (Bolman & Deal, 2008, p. 248). Humans attempt to make sense of the world through meaning, belief, and faith. Symbols are the root of meaning systems and often take the form of myths, visions, heroes, and ceremonies (Bolman & Deal, 2008, p. 249). These frames become important windows providing insight into the role desktop virtualization can play in schools.

On the human, political, and structural levels, individual needs should be met and roles should be clarified. Lines of communication need to be opened between the virtualization project head and key decision-makers, such as the superintendent, CIO, principals, teachers, and school leaders. A strong relationship between these individuals and the corporate vendor of choice is crucial. All information about the project must be shared and discussed thoroughly. Regular Q&A sessions and feedback are necessary. A virtualization symposium may help enrich all involved in the decision-making process. After the agenda is clarified, decision-makers should communicate with the corporate consultant and begin to set the exact parameters of the project. The superintendent and CIO will have the most decision-making power, but teachers and other school leaders should be regularly consulted to shed light on how virtualization will benefit students at the teacher-student level. Clearly, the vision should be shared amongst decision-makers and group unity and dedication to achieving the vision is paramount.

Symbolically, the strength and rising value of the PG County school system should be accentuated and posters/videos should be available to proudly herald the vision of virtualization for all within the school system and community to see. Transitions to virtualization should be marked and the strength of the community and its schools should be reified.

Attainable objectives, skills, and incentives are also vital to discuss and outline. From a human frame perspective, the objectives should be agreed upon between decision-makers. Objectives should satiate teacher, principal, superintendent, CIO, and student needs alike. Each player should feel he or she can trust each other and share a sense of ownership in the process. Objectives should reasonably include making desktop virtualization a reality in such a way that costs are reduced and education is enhanced, outlining skills that end users and IT professionals will need to successfully use and maintain virtualization capabilities, projecting various ways that virtualization will statistically improve school learning in class learning environments (perhaps by helping to raise standardized test scores and classroom grades), highlighting incentives endemic to the process such as reduced costs which will translate to more money going toward software purchases, curricular progress, and other classroom learning needs.

Politically and structurally, objectives, skills, and incentives should be clarified specifically, openly, and with an eye toward satiating all decision-makers. Negotiation will be a critical tool at this point. Administrative and staff support is necessary. All involved should sit down and clarify the skills necessary to achieve the objectives. Specifically, the following question should be asked, "What skills will end users, IT professionals, and administrators need to implement and maintain desktop virtualization?" These skills may be squared around state standards and individual school goals. Corporate and federal partnerships will need to be made so that all involved are properly trained to use virtual technology and positioned to receive economic and software incentives from the national government and software vendors.

Symbolically, PG County needs to promote the objectives and incentives of desktop virtualization on a grand scale and get the entire county behind the project. Posters, mailings, video demos, and word of mouth can go a long way in helping the cause.

Resources need to be considered carefully before, during, and after implementation. From a human frame perspective, funds may come from district, school, and corporate sources. In the case that initial implementation costs run high, seasoned grant writers should be asked to step up and help attain further state and federal funds. Resources should be allocated in such a way that the individual needs of all decision-makers are met.

Politically and structurally, partnerships need to be formed with corporate outlets. Software companies and school-friendly corporations should be consulted as potential partners in footing the bills, especially in the realm of software application licenses. Fundraising events may be necessary and private donors may need to be wooed. It is also important to do an inventory of the current infrastructure within county schools. Decision-makers should determine how many currently functional PC's may be used as thin clients. Some already existing components of the computing infrastructure may be usable which would save on installation and implementation costs.

Symbolically, fund drive posters may promote the project and advertisements supporting particular software needs could adorn computer labs. The idea is to continually celebrate where the school has come from and where it is going in relation to computer technology. Students should be actively informed about and take part in activities that support desktop virtualization. They should feel ownership over the project. After all, it is their school system as well.

Milestones and monitoring plans should be implemented and observed diligently. On the human front, milestones should be highlighted individually and collectively. The idea is to empower individuals and the school system as a whole. Monitoring/evaluative parameters should be decided on by all those involved and "success" should be carefully defined in educational and financial terms.

Politically and structurally, the superintendent will need to keep track of milestones (choice of vendor, initial implementation report, student and financial progress) carefully and report back to all parties involved. Success should be reported as it relates to standards decided upon by all decision-makers and players. A cost and efficiency review should be conducted monthly to bi-monthly and any deviations from progress should be noted and addressed immediately. IT employees should be monitored carefully on a monthly basis to confirm that they are operating the equipment correctly, efficiently, and safely. Corporate partnerships should also be monitored closely and be terminated if proven to be cost-ineffective.

Symbolically, milestones and monitoring goals should be proudly displayed throughout each school. Posters honoring personal and collective milestones should be created. Online monitoring charts can be a useful and efficient way of tracking progress financially. Teachers and principals need to give input as to how progress is occurring at the teacher-student level.

Finally, roadblocks need to be acknowledged and addressed. As mentioned earlier, data security is an important issue. On the human level, it all comes down to trust. Everyone involved must trust each other. In particular, the IT employees must be especially trusted because they control much of the data storage capability and monitor the virtual infrastructure closely. The success of implementation also depends on individual "know-how." For example, if teachers are not learning how to implement virtualized technology into a class setting, it may be difficult to monitor the degree to which virtualization advances student learning. Time may also be an issue. Implementation should ideally take place when school is not in session so that class time is not disturbed. It may be difficult to accomplish this at PG County given the enormity of the student population and sheer number of schools in the system.

Politically and structurally, IT staffing, available school space for computers, current computer resources, and budget may cause issues. It will be important for all key players to discuss these issues often with as little power-play as possible. Ultimately, the students and towns will benefit, so egos should be left at the door. Symbolically, it will be important for PG County to promote desktop virtualization without scaring traditionalists who are akin to paper-based methods and averse to technological change. Those who believe that technology may destroy previously held notions of culture need to be reminded and encouraged to use virtual technology in a way that promotes the school system and respects all educational philosophies.

DIRECT APPLICATION AND ACTION PLAN

The process of bringing desktop virtualization to PG County physically begins with a professional consultation. A corporate consultant will meet with the PG County school superintendent, CIO, and other designated principals and school leaders for a demonstration followed by an extensive question and answer session. This

demonstration will be arranged based on and geared toward the computing climate of the school system. The corporate consultant will review information that the school has provided him and create a demonstration that will specifically fit PG County. A corporate consultant will take statistics relative to total cost of ownership, previous PC maintenance costs, and licensing costs and further probe into how and where money is being spent relative to school computing and come up with an individualized implementation plan designed to specifically help PG County. For example, the consultant will probe deeper into how many computers the county has freed up for school use. This will help in determining how many thin clients will need to be introduced into the infrastructure. PG County has many existing computers that can be used as thin clients which will cut implementation costs significantly. He or she will also investigate current PC maintenance costs and investigate the utilization rate of the county's underlying PC physical hardware. Further, the consultant will look at application complexity and associated costs and look at the need to potentially reduce IT costs across the board.

Educationally, the consultant will curtail a report as to how desktop virtualization will benefit PG County based on respondent information. The desire for more flexible, storage-capable, and centralized PC use in their schools will be gauged. PG County school leaders may potentially be highly interested in the educational advantages of desktop virtualization but may know little about how it can be expanded to home use so that end users can access the school server even from their bedrooms. The consultant will discuss this potential in the context of his or her proposed solutions for PG County. Clearly, security, flexibility, licensing, personalized classroom instruction, and increased educational performance will be key issues of action. Educational software and potential corporate partnerships will be discussed and the PC County decision-makers will watch a video demonstration confirming the many ways that desktop virtualization has saved other school districts money while increasing educational benefits. Together, security threats, compliance risks, management costs, administrative inefficiencies, resource utilization, and educational benefits will be discussed in depth.

After PG County has accepted an offer from a corporate virtualization vendor, the process of implementation begins. Corporate consultants and IT professionals will visit the schools and begin installing the virtualization equipment. This could be an extensive process for PG County because the school system is large. The consultants will assist in answering questions throughout the installation process and the IT professionals will help train local IT staff and end users to use and maintain the virtual infrastructure. There is bound to be a learning curve during this time as end users and IT administrators ease into the new infrastructure. During the first months and year of implementation, PG County school officials and staff will begin to see the benefits of desktop virtualization. Lower costs and educational benefits are the hallmark results of this implementation.

Any issues that may arise during implementation must be addressed in an expedient manner. IT professionals are the primary go-to source to resolve these issues and corporate consultants and IT professionals can also be summoned for support if need be. Once the virtualized infrastructure is fully implemented, administrators can begin to analyze financial savings and teachers can begin to teach with confidence in a virtual system that allows for greater educational flexibility and breadth.

CONCLUSIONS AND FUTURE APPLICATIONS

The potential results of implementing a virtualized computing system in PG County schools are bound to be overwhelmingly positive. PG County is bound to save money and gain a great deal of flexibility as a result of implementing virtual technology. With a large PC infrastructure already in place, many of the PC's can be used as thin clients and broken PC's can be easily replaced with lower cost thin clients. Virtualized infrastructure access provides central management, back end user data storage, and policy-driven security. These allowances are bound to reduce energy costs in a school system of nearly 200 schools. PG County administrators will be able to access administrative applications from any workstation with increased security due to centralized data storage. This will help administrators be more efficient, which is crucial in a system containing 123,000 students. Counselors and health professionals will benefit from having access to all required school and student information from any workstation. IT staff will be able to centrally manage all desktops which will make their lives easier and remove the need for PG County to employ numerous IT professionals. Finally, students will have secure, consistent, and reliable access to educational applications and individual data from workstations in all classrooms, labs, and even at home. This access flexibility will help improve student learning by increasing student productivity and access to computer-

based educational tools that supplement lessons. Students will also gain more hands-on interpersonal experience as virtual capabilities allow for student interaction with applications and each other. Overall, virtual implementation will thrust PG County to the forefront of computing technology which will earn the district increasing respect and national attention.

Recommendations for PG County once virtualization is in place are as follows:

1. First, it is recommended that decision-makers and school leaders meet often to discuss the state of affairs in virtual computing. This means that administrators should confer with IT staff members, teachers, school leaders, and students alike to assure that desktop virtualization is working well financially and educationally. Reports with these findings should be made available to all those in the school community and to the PG community at large. Certainly these results should be posted online. After at least two years, if it is proven that virtualization is not working, administrators should not be afraid to pull the plug. Patience is a virtue and no decisions should be made before ample time is allowed to adapt to the new technology.
2. Further, students and learning should be made top priorities. Administrators must partner with teachers to provide students with an optimal learning environment. This means that curricular planning should take place with virtualization capabilities in mind and software should be purchased that piques student interest and enhances learning. It may mean that decision-makers should consider exploring home-connectivity options on PC's, cell phones, and even portable game consoles. This will further excite students and encourage them to associate their own electronic devices with learning.
3. Finally, it is important to remember that desktop virtualization is not the second coming. It will not solve all problems as technology moves too rapidly to have single solution. Virtualization will likely be one of several tools that a school will have to employ to get applications and enhance learning. The traditional method of installing applications on a client machine is not going to disappear because there will always be applications that cannot be virtualized. Further, it important to understand that virtualization will not completely replace the paper-based academic culture that has traditionally permeated classrooms; it is a supplement to it and should not be used as the sole format from which students learn.

AUTHOR INFORMATION

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