ESSENTIAL COMPONENTS OF A HIGH-TECH HIGH SCHOOL

by

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(Under the Direction of Dr. C. Thomas Holmes)

ABSTRACT

There are few published standards for local educational professionals to use when designing a specialized technology instructional facility or high-tech high school. The purpose of this study is to determine the essential facility components when designing and building such an educational facility. The research question was derived from a void in the research or practical literature providing school or district level administrators a guide in the planning for and creation of a facility specifically devoted to instruction in high-end technology programs. A list of facility design components as considered essential by Chief Information Officers of local school districts and the local school technology coordinators/technicians in designing a high school facility focusing on technology programs of study and to determine if the two groups agree on essential elements of school design will be the result. The resulting list will serve as a resource for school/district administrators looking for a starting point when faced with designing a high tech high school.

A Survey Instrument was sent to two sample respondent pools of Chief Information Officers for school districts and school based technology coordinators as the study sample pool. The instrument asked respondents to identify what they believe to be essential elements to include in an educational facility focusing on instruction in and using the latest technology from a list constructed from a search of current literature. The Survey Instrument's purposes were to rank order per respondent group the list of possible essential facility components and determine how closely the two respondent pools were in agreement on the listed essential facility components.

The study revealed that school district chief information officers and school based technology coordinators did not agree of what essential components need to be included in a high tech high school. However, in ranking the components in the study the two groups did agree on three of the top five items. Those three items were all in the technology infrastructure category.

INDEX WORDS: School design, Instructional Technology, Technology Infrastructure, School design, School construction

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CHAPTER 1

Introduction

A direct correlation between the condition of a school building and its effects on student achievement has been found in many studies (Berner, 1995; Bingler, 1995; Fiske, 1995; Lackney, 1999; Lyons, 2001). The introduction of technology into school design and curriculum has improved student achievement. That school facilities affect learning (Schneider, 2002) is accepted by many researchers. However, identifying which component has the most effect is complicated by many variables. One of those variables is the process of integrating technology into school facilities and curricula. Advocates say student increases in knowledge and performance in academics and on standardized tests are direct by-products of integrating and infusing computers, internet access, and other forms of technology into classrooms, media centers, and campuses across the nation (Lyons, 2001, Moore & Warner, 1999). Opponents say that the enormous amounts of money spent to supply schools and teachers with technology has shown little improvement in student achievement, as evidenced by national and international standardized tests (Balfanz, 2002; Stricherz, 2000; Wenglinsky, 1997; Woolard, 2004). Another argument against expenditures on technology is that 79% of higher education institutions offered remedial education courses, and 29% of freshmen engaged in remedial classes at the post-secondary level after attending technology-rich secondary schools (Alford, 2004). In addressing this perceived failure of the traditional high school to adequately use technology to prepare American students to compete in the global economy of the 21st century, a wave of specialized technology-focused high school programs have emerged. These programs provide an alternative way to educate students who are highly motivated to use and achieve through the use of technology. In school districts of every size, schools have been proposed, designed, and built for specific instructional programs focusing on technology to engage and prepare students to be successful in all types of technology instructional programs, ranging from the generic to the industry specific. By effectively designing an educational facility to meet specific program learning goals, educators can ensure that students “think and create with technology rather than simply learning from technology” (Means, Penuel, & Padilla, 2001) and improve student success. Technology is not the focus; learning was. Therefore, designing a facility to house a unique educational program must consider that uniqueness and not be forced “to fit a round idea into a square hole.” A good fit would be if a school district were able to build schools on time and on budget using a template design that would be considered a bonus for the school system, board of education, community, and taxpayers.

The design of many specialized high schools in the last few years has often been a collaborative process between architectural and industry professionals, school or district office technology coordinators, interested parents and/or other community members, post-secondary technical/community college and university professors, teachers, and sometimes even students (Bingler, 1995; Hardt, 1998; Holcomb, 1995). This design by committee worked, with often the building-level administrator as the project coordinator pulling the bits of knowledge and opinion together toward a goal of designing the best facility to meet student needs and hopefully incorporate long range plans for changes and upgrades to the facilities (Argon, 1998). Collaboration has proven successful through involving many stakeholders, but buildings are planned and designed without the assistance of research data that gives insight into the best practices in the field of design and construction of these specialized instructional campuses (Argon). "A school building does not merely house the instructional program, it is part of the program" (Hawkins, 1995, p.44). Given the growth and change in technology, "it's important that you do all you can to ensure that the design of infrastructure, systems, and other components of applied technology meet your educational requirements now and in the future" (Valiant, 1995, p. 62). It was valuable to identify a list of the essential components considered necessary in designing and building a specialized-technology high school facility of specialized-instructional settings, as a starting point for planning a facility. For the purposes of this study, a high tech high describes an educational facility built to provide a facility for instruction of a variety of programs of study that all involve industry-standard levels of technology. Buildings of this type often have a nontraditional school physical plant designed to look more like high tech businesses than schools, but not exclusively.

Statement of the Problem

The problem is that there are no published standards for local educational professionals to use when designing a specialized technology instructional facility. Some recommendations by national organizations and independent researchers suggesting what should be included into the facility design of a high-tech high school are available (Earthman, 1992; Means, Penuel, & Padilla, 2001; Westbrook, 1997; Whitehead, Jensen, & Boschee, 2003), but none provided a synthesis of thought. The purposes of the study were (a) to develop a list of facility design components that chief information officers of local school districts and the local school technology coordinators/technicians considered essential to designing a high school facility, focusing on technology programs of study; and (b) to determine if the two groups agreed on essential elements of school design. The resulting list will serve as a resource for school/district administrators looking for a starting point when faced with designing a high-tech high school.

Limitations

A comparison will detail only the essential facility components indicated as essential, based on the level of expertise and knowledge of the respondents. Budget constraints and other variables will not be a controlling factor, therefore making the list of essential components less definite and more of a starting point for subsequent practitioners using the list as they design and build these types of facilities. Follow-up studies are necessary in many areas, including cost-versus-return in the area of student performance to justify expense and determine feasibility and sustainability of these specialized facilities.

With rapidly emerging technologies, the study did not cover every conceived technological innovation. Thus, the study will need to be replicated in the future to keep the list of essential facilities components current.

Justification of the Study

Several guides exist from national organizations and certain researchers that list components for consideration when designing facilities incorporating technology (Earthman, 1992; Means et al., 2001; Westbrook, 1997; Whitehead et al., 2003).

Long-range planning, allowing for technological changes in the plan, potential effect on instruction, costs, orientation, professional development, and evaluation make up most of the guides currently available to the school or district administrator who often gets handed a specialized project, such as building a technology-focused instructional program and facility. However, no one guide provided the essential components--as considered by CIOs of school districts and local school based technology coordinators that have gone through the trial and error of this process--to help local administrators plan and build new technology programs and their supporting facilities. As Hoffman, a CIO for a school district that has recently completed a similar project, stated, "In addition, I might have spent more time talking to people in other districts that have done this kind of work before" (Fickes, 2003, p 18).

Research Design and Methodology

The study consisted of a survey of the sample groups. The Survey Instrument was administered via the Internet and asked respondents to identify what they believed to be essential elements to include in an educational facility focusing on technology instruction, and a comparison of the rank orders of these components determine if there was a statistically significant difference in the rank order of the essential components between the two groups. For this study significant testing was performed based on $\alpha = .05$. However, due to the exploratory nature of this study, findings significant at $\alpha = .10$ were noted to suggest trends for future research.

Sample

Two sample groups consisted of school district based chief information officers (CIOs) and local school based technology coordinators in the respondent pools. Participants' names and contact information were obtained from membership rolls of the National Association of Specialized Secondary Schools in Math, Science, and Technology and the National Academy Foundation.

CHAPTER 2

Review of Literature

The main emphasis of investigation in this paper is identifying the essential components to include in the facility design of a special high school facility where high-end technology instructional programs are offered to students. The Survey Instrument identified as Appendix A queried respondents on their opinion of the essential components included in a high-tech high school. Each survey question had either a research study or anecdotal citation on the chart included as Appendix B, indicating its inclusion value. The research was divided by survey category. A limitation to this review was that few empirical studies have been conducted on the topics of individual survey questions identified on the instrument. Most citations are from researchers and experts whose opinions are derived from practical experience. Advisory councils, local and district school administrators, technology coordinators, parents, business and postsecondary institute representatives were a few of the stakeholders often involved in the design and implementation of this type of facility. Lessons learned were often included anecdotally in articles and research papers and include comments to help subsequent individuals undergoing this process such as, "We know that despite the success of a committee structure, one organization must take responsibility for leading and managing the process" (Boettcher & Morrow, 1995).

Integrating technology to support instruction needs to be the focus of any high school facility, but was essential for those focusing on high-end technology studies. When designing specialized technology educational facilities many experts, as noted in the literature, concluded that technology is not a solution in isolation, but rather a key component that allowed schools to address core educational challenges (NASBE, 2001). Special emphasis facilities can become the pride of a community due to the quality of students educated as well as the design and implementation of the technology housed. Therefore, special care, attention, and planning go into a design. A Superintendent of Tishomingo County, Mississippi schools put it another way; "There is a lot of pride in this facility on the part of everyone in the community. Even the students treat the place with respect. There are no graffiti, no skid marks, and negligible vandalism. Beyond that, the facility seems to promote academics somehow" (Bingler, 1995. p.28).

Category 1 - School Organization

The term school organization, as used in this study, referred to the physical structure, curriculum, and/or scheduling that may be part of the holistic design in a specialized educational facility. Schools were organized around everything from grade levels, daily schedules, attendance zones, specialized programs of study, comprehensive curriculum, half-day, and full-day, and/or magnet programs. Too many variables existed in these categories for one study; therefore certain variables were identified for inclusion as survey questions on the Survey Instrument (Appendix A).

A large body of research supported the concept of building a high school facility that supports no more than 1,000 students, either in total, or in small learning communities segregated inside the facility (Berner, 1995; Fiske, 1995; Cotton, 1996; Gewertz, 2001; Kennedy, 2001; Lyons, 2001; Moore & Lackney, 1995; Nathan & Febey, 2001; Stevenson, 2002). Smaller schools and smaller classes reported higher achievement (Gewertz; Stevenson), fewer discipline referrals (Nathan & Febey), more personalized relationships with the students (Kennedy, 2002) and more community orientation, as they were placed in neighborhoods with smaller plots of land or in nontraditional spaces (Lackney, 1999). Nathan and Febey's (2001) analysis reviewed 22 case studies of public school buildings in 12 states, illustrating how smaller schools sharing facilities provide safer, saner, more successful schools.

Schools had wide methods upon which to organize their physical plant, school calendar, and student schedules. Calendars were often the toughest area for change in a school, but reports indicated that specialized technology schools had a variety of yearly and daily calendars (Lyons, 2001; Thornburg, 1999). With the focus on specialized education as well as organization around career academies, many researchers felt that flexibility in the daily schedule allowed for the personalization of instruction for students (Lyons, 2001; Moore & Lackney, 1999; SREB, 2003). However, with a menu of options for school schedules, Boettcher and Morrow (1995) reported even with changes, the process does not get easier from year to year.

Lyons reported in 2001 that the average U.S. high school campus construction cost is approximately $26 million. Specialized high school costs are often more expensive, thus schools and their districts have entered into joint build-and-use agreements sharing facilities such as Virginia Beach City and its local community college (Cutshall, 2003). Sharing of facilities makes sound fiscal sense as, "rapidly changing technology requires constant monitoring to make good investment choices" (Boettcher & Morrow, 1995, p.136), and both programs benefit from the joint facility, equipment, and expertise of staff from both levels. Some districts have looked beyond just postsecondary institutions as partners, such as the case of the Tishomingo County, Mississippi Education Complex, which was intentionally built to house a variety of programs, from daycare, to secondary, to postsecondary offerings (Bingler, 1995). "By sharing space, educators, students, and citizens can gain access to a fuller, often better range of programs and services" (Nathan & Febey, 2001, p. 13). Nathan and Febey also reported that, "School buildings that share space with other organizations can provide youngsters with a better education and use taxes more efficiently" (p. 13).

The Southern Regional Educational Board's High Schools That Work initiative supported a rigorous academic comprehensive core of classes in conjunction with a technical concentration of study based on accepted industry standards (Bottoms, Presson, & Han, 2004). Many school districts adopted their own competencies or performance standards using industry expectations as their guidelines. Webb (1999) described one district's listing of competencies that were adopted straight from industry standards. Some viewpoints mandated providing industry-standard technology to teach that level of curriculum as an essential component to designing a high-tech high school (Cutshall, 2003; Wright, 2003).

Ward (cited in Fielding, 1999) stated that larger classroom space (1,200 + sq ft) allows for more collaborative work by students and integrated, activity-based, technology-integrated instruction. Larger classroom space allowed more flexibility in room use and configuration of instructional space.

Category 2 - Instructional Spaces

Schools today may not serve the same purposes or provide the same methods of instruction, as they will 40 years from now. Facilities need to be designed with flexible spaces in order to address any future changes in programs. Holcomb (1995) indicated,

> In the design of an educational facility, the challenge in defining the educational program to be housed in the new school is not actually to pre-decide what form education is to take during the lifetime of that building, but rather to design an education system which can retool itself to meet change as this change unfolds. (p.17)

He also reported that flexibility is one key to good design to best utilize space, time, and grouping for instruction.

Increasingly integrated curricula, project-based learning, and authentic assessments were a few of the instructional and assessment techniques facility designers considered when designing a high-tech high school. Lyons (2001) stated that the links between subject areas to the real world increased the necessity to have space for teachers to collaboratively plan activities and students to work together cooperatively. Information technology as a curriculum should be taught; however, those skills were essential knowledge that can be applied across the curriculum (Whitehead, Jensen, & Boschee, 2003). Successfully teaching students that computers are an integral tool for communication and for use in gathering and disseminating information was a mandatory lesson in today's interconnected global society (Gayeski, 1995).

Adequate lighting, generally 50-100 ft candles, was recommended by Loomis (1995). Loomis also recommended "in classrooms or other group presentation areas, control of the light system must be conveniently provided for the present, ideally with a programmable wireless controller" (p. 72). Ease of instructor access to controls for the technology instructional tools are essential to the utilization of that technology, so that the teacher is not held captive behind the podium. Rather, events can be controlled from “anywhere in the room with the remote control" (Chilton & Dalen, 1995, p. 127). There were three major goals in the design and construction of a technology podium or centralized control panel. These concern security, flexibility, and durability, according to Boettcher and Morrow (1995). Ease in servicing the podium or centralized location, making sure it is mobile and does not impede the line of sight, and security of the equipment while making it readily accessible, was all possible uses (Boettcher & Morrow, 1995, p. 136). In buildings undergoing renovations to reinvent their space Boettcher and Morrow suggested using two different strategies in the older classrooms through adding new incandescent lighting and adding light switches that give the user only one or two banks of lights at a time as a practical, cost-effective solution.

If students and teachers are issued laptop computers, then having adequate and conveniently placed plug-in stations in the Media Center and classrooms was imperative (C. Collins, personal communication, May 14, 2004). Kennedy (2001) reported that as colleges and postsecondary institutions were requiring laptop computers of their students, they were designing new buildings with plug-in stations with wireless capability and easy access to electricity.

Federal law requires that all facilities meet the standards of the Americans with Disabilities Act (1990). Accessibility of technology was not only mandated by the American with Disabilities Act law, but by the necessity of students being prepared to enter today's workforce. Thornburg (1999) noted that computers should be accessible to every student. Also, all programs of study and equipment used within those areas of study must be accessible to students and teachers with disabilities. However, major reconstruction and expense was not the main purpose of the Americans with Disabilities Act (Gonzales, 1995). With today's computers few barriers remain that exclude students from being able to engage in the study of these programs. Computer-based classrooms and technology aids abound to help schools meet the requirements of the American with Disabilities Act (Gonzales). "In paying attention to accessibility issues for special needs students, schools are discovering that all students approach content in unique ways" (Shorr, 2004, p. 1). Further, keeping these issues in mind insures that all students with disabilities were given the opportunity to participate fully in life and learning (Barton, 1995).

Video production and editing equipment costs have been reduced greatly over recent years. Hardt et al. (1998) reported, "The cost of a video production is more in time than in equipment" (p. 61). A high school television studio "can be as simple as a corner of an existing media center storeroom or main library area, although larger areas offer greater flexibility in set and shot selection, but most school facilities tend to be good dimensions" (Hardt et al.,1998). Major considerations for facility designs that include a video production and editing suite were: (a) separate electrical circuit; (b) specialized lighting; (c) sound baffles; (d) audio equipment to adequate fit the size and space designed; (e) lockable storage area; and (f) control room windows facing away from set, but with ability for teacher to easily monitor both activities involving students (Hardt et al., 1998).

A well-designed educational facility should provide teachers with a physical space that promotes their professionalism and focuses on integrating and using technology with instruction. Teachers did need areas for relaxation and socialization, but the state, district, and/or school leadership should protect and ensure that teachers have adequate space dedicated and equipped for professional endeavors (NASBE, 1996). The American Society for Curriculum Development (ASCD) recommended that school designs include teacher conference space, storage, and small group workrooms (NASBE, 1996). Ancillary benefits of fostering a professional climate include improved working conditions that attract and hold outstanding teachers (Moore & Lackney, 1995). "They (teachers) must be regarded as professionals, treated as professionals, and consider themselves to be professionals," observed Moore and Lackeny (p. 14). Fiske (1995) stated, "If we are serious about the notion that American teachers are professionals, then schools must provide them with space in which they can engage in professional activities" (p. 6).

Category 3 - Instructional Tools

Instructional tools in high-tech high schools were so numerous that facility planners must understand the programs of study offered and how instruction will occur in the physical space housing those programs before deciding on essential components. The difficulty in forecasting what will be needed in 10, 20, or even 30 years is large, yet planners are asked to decide how to build and equip just those spaces in a economically efficient and instructionally sound method. Besides a warm or cool and dry place for instruction, teachers should be prepared to use the technology provided. The most pervasive need expressed in the literature review was not the need for more technology, but for adequate teacher training to use all the technological tools provided for instruction (Boetcher & Morrow, 1995; Bransford et al., 2000; Cutshall, 2003; Edwards, 2004; Murray, 2004; NASBE, 2003; Thornburg, 1999; Valiant, 1995; Woolard, 2004). Many researchers and commentators noted that to successfully implement any technology-infused instructional program, extensive professional development and training was necessary (Boettcher & Morrow; Bransford, Lin, & Schwartz; Edwards, 2004; Leverett; Murray; NASBE; Shorr; Thornburg; Valiant; Woolard). Yet, "Nearly half of the school leaders surveyed from large districts (45%) said that the lack of technological understanding on the part of other district employees poses a significant barrier" (Murray, 2004, p. 25). This lack of preparation was pervasive and, school leaders admit they themselves lack the skills to integrate technology effectively. According to the survey [Grunwald Associates survey sponsored by CoSN released June 10, 2004 of 455 school district technology decision makers] fewer than one in 10 school leaders (7percent) would classify his or her ability to integrate technology into the learning environment as 'very good' or better. Further, most school leaders contend classroom teachers need even more help. In one study, on a scale of one to 10, respondents gave teachers an average score of 5.3 on technology competence. (Murray, 2004, p. 25)

The pros and cons of providing students with handhelds and laptop computers were numerous. With budget constraints aside, "Handhelds and laptops are the heirs apparent to the computer lab for the 21st century school" (Cook, 2002, p. 2). Handhelds were less expensive and loaded with educational software, and school administrators were looking at handhelds as a less expensive option to laptops (Shorr, 2004). Whitehead, Jensen, and Boschee (2003) stated that as wireless capabilities expand laptops and handhelds, both become more commonplace in the instructional setting. Already, these tools were indispensable as administrators and teachers reported that "having all my information with me wherever I go-from names, addresses, calendars, and phone numbers to databases with passwords, professional development events, and log-in information for the networked computers in the district" (Poftak & Gold, 2004, p. 1) was a boon to communication, records access, and note taking.

Districts and states that had implemented laptop programs learned what to do and not do, by sharing best practices. They reported that the achievement gains of students outweighed the cons of cost, implementation, or maintenance of issuing students laptop computers (Cook, 2002; Rush, 2001; Thornburg, 1999). Benefits other than document processing emerged as students and staff have been issued laptop computers, allowing them access to Web-based information and better communications (Strange & Banning, 2001). The State of Maine reported, "Deploying 25,000 wireless-capable laptops has engaged our students, enlivened the learning environment, and moved us toward the kind of equity of opportunity that ought to be at the heart of our democracy" (Edwards, 2004, p. 1). Not only students, but parents are connected to teachers and school resources as well as the World Wide Web.

Using the Internet as a source of information has become de rigueur for today's classrooms. "In fact, the most recent figures from the U.S. Department of Education indicate that schools (99 percent) now have Internet access, with 87 percent of individual classrooms having access" (NASBE, 2003, p. 7). With this level of connectivity, students had access to instruction anytime, anywhere, through districts offering online learning, and teachers can access professional development opportunities offered through a variety of sources. According to a survey by Grunwald Associates commissioned by the National School Boards Foundation school district leaders, "plan to deliver a substantial portion of daily instruction via distance learning to more than 20 percent of their students by 2005" (Shorr, 2004, p. 1). Once again, adequate teacher training to use the technologies for online teaching and learning was paramount (NASBE, 2002).

The amount of time spent preparing a computer-integrated course was dramatically greater than its paper counterpart. Sometimes a school used course materials that already have been packaged for the purpose (Rush, 2001) or they developed their own based on district standards. The course package or platform should have been sensitive to the teaching conditions: Who is being taught? What is being taught? When in the curriculum is it being taught? (Rush, 2001). According to NASBE,

> Once an interactive lesson or online course has been developed according to evidence-based design principles and academic content standards, and then proven to be educationally effective, it can be made available to any location where the necessary on-site resources are available. (NASBE, 2003)

They further stated that “students [and teachers] in a well-run 'networked learning community' will be able to access the best educational resources from across the globe at any time of the day and year" (NASBE, 2001, p.4), and that "e-learning will improve American education in valuable ways and should be universally implemented as soon as possible" (NASBE, 2001, p. 4). The Director of the Office of Educational Technology for the U. S. Department of Education commented that "virtual education - virtual schools, online professional development, online tutoring - is another powerful solution that expands educational and professional development opportunities any time, any place" (Scholastic Administrator, 2004, p. 46). Such comments speak loudly to online learning's current and future impact on education. With the growth in online learning, the traditional school facility should include learning spaces and scalable technologies to support this type of instructional delivery, including an e-mail system that included students. The school building will not disappear to become one large networking closet. As Leverett (2001) reported, "The schoolhouse is still an important place in our community for young people to come together to learn and experience the socialization needed to prepare for adult roles," (p. 1) but the physical layout should look significantly different.

With the shift to more Web-based instruction, it would seem reasonable that those courses would use e-textbooks. However, no definitive protocol or format has been developed for e-textbooks to be uploaded into the various hosting platforms for online courses (Rose, 2000). Publishers noted a concern that teachers reported spending more time developing and teaching online, without extra pay, and some are resistant to incorporating online textbooks into that mix (Rose, 2000). As e-textbooks are graphics intensive they had yet to fit on handhelds, thus reducing their portability, which was a complaint of students (Blumenstyke, 2001). The pros will eventually outweigh the cons of e-textbooks as publishers work out the kinks, because students reported they enjoyed the interactivity and links provided with these texts and were able to be more focused on the instruction (Rose, 2000).

A school principal reported that giving the teachers the capability to capture and control the students' laptop screens during class instruction was a necessity (C. Collins, personal communication, May 14, 2004).

<u>Category 4 - Technology Infrastructure</u>

The term *technology infrastructure* refers to a school's design that supported the inclusion, implementation, and use of technology in a school building and could include any characteristic from voice, video, data, audio, security, and environmental control systems, all of which are necessary to transmit information throughout the building (Hardt et al., 1998) and beyond. At the classroom level, "an information-age classroom must not emulate the isolated cocoon of the industrial-age classroom. Rather, the information-age classroom must be a virtual classroom with data, voice, and video access to the world" (Boettcher & Morrow, 1995, p. 139). Hardt et al. (1998) reported that using a standards-based approach to providing for a facility's technology infrastructure could reduce premature obsolescence of hardware and was more scalable and adaptable to change.

Key communication components for inclusion as standard varied from voice, video, and data IP in classrooms or other centralized locations. After an analysis of the programs to be offered, decisions should be made on type of equipment and placement of that equipment. Voice, video, and data lines should not be considered separate entities into the school facility of today (Hardt et al., 1998). Nor should traditional forms of communication such as the telephone be discarded in the wake of other data forms of communication. One school reported its Parent Line, an automated voice-response system that lets parents phone in to the district for their child's attendance, grades, and other information, was invaluable to them, as few parents had Internet access at home (Poftak & Gold, 2004).

No school building should be completely wireless, with today's technology. A school's cabling system will influence its ability to access information and communication tools that require large bandwidths. Therefore, attributes of a structured cabling infrastructure include: (a) an entrance or demarcation point with largest possible carrying capacity to handle higher and higher network speeds; (b) a dedicated, locked head-end room with windows facing the Media Center; (c) a dedicated HVAC and electrical systems; (d) a backbone and horizontal cabling; and (e) a work-area subsystem that is simple to modify and accommodates different applications (Hardt et al., 1998).

The National Center for Education Statistics (2004) advised facility designers that a "solid defense against external network threats include encryption software; virus scanners, remote access regulations, passwords, and firewalls" (p. 1). Tension can develop between tech security, innovation, and users, but growing concerns over hacking and exposing students to inappropriate materials online has heated this debate between those who consider themselves, "the keepers of educational pedagogy and those who safeguard network security" (Shorr, 2004, p. 28). Remote access to a facilities network was an efficient tool. Users report: "The fact that I can monitor the school server from home. It lets me know much sooner if a problem exists and I can respond more quickly in an emergency" (Portal & Gold, 2004, p. 1). A well-designed facility must include a constantly evaluated security plan, because of this very access.

Technology laden facilities must have "better than average" HVAC and electrical systems (Hardt et al., 1998; Holcomb, 1995; Kennedy, 2001; Moore & Lackey, 1995; NASBE, 1996; Shorr, 2004; Yung, 1995). Heaton (1995) noted that, "Air temperature and quality are probably the most named detractors of learning" and rapid changes in temperature are harmful to some technological equipment. Yung (1995) wrote that for facility planners basic areas of concern when designing power systems should include: (a) adequate power (amperage) to run the necessary lights and equipment; (b) sufficient number and appropriate placement of outlets; and

(c) adequate consideration of any possible flow of data in or out, when considering wiring a room.

Security cameras are looked on as common design elements for secondary facilities. Benefits included those found in this anecdote,

> There's nothing like being able to go right back to the incident without all the investigation, where this kid says this and that kid says that. It (security cameras) makes the school more secure, we have documentation for accountability, and it feels good to help the innocent victims. (Poftak & Gold, 2004, p. 1)

The head-end room was the hub of a facility's technology. A head-end room's physical location in a building was important, as the controls for all information and data usually started and stopped at this point, entering a building (Hardt et al., 1998) and they were usually located adjacent to a facility’s media center near the center of a high school. To adequately design this space many factors must be reviewed, including: (a) types of devices to be housed in the room, (b) whether or not phone and video systems are housed, (c) number of people interacting with the equipment, (d) ample power and additional air handling and cooling capability, and (e) storage space .

Category 5 - Common Areas, Furniture, and Decor

The common areas, media center, furniture, and décor of a high-tech high school facility were part of the concept of communication of the high-tech instructional nature of the facility (Moscoe, 1995). In addition, "this space must accommodate a wide range of activities and products, including, but not limited to, audio/visual studio productions, live performances, mathematics projects, individual project work, large open project tables, a gallery to display work, and staging areas” (Moore & Lackney, 1995, p. 21). Barton (1995) found computers were so frequently used in media centers because they are on easily accessible desks.

A fully wired media center was a given in today's construction models. However, a high-tech high school would need an exceptionally well-designed and integrated facility, including a production lab for students, meeting spaces, and access to technology for study and research (Hardt et al., date). Hardt et al. reported that with the shift away from print to technology resources for information facility designers must give consideration to designing a media center for the most future flexibility. In this technology-rich environment, a well-designed lighting plan was critical, and although daylight may be a good option for the media center during the day, additional lighting should be considered for evening use (Hardt et al.).

One of the most powerful affirmations of the quality of instruction occurring in a building was to display student-created work. Moscoe (1995) noted, "A display surface is an element within a communication environment which enables or aids the communication of a message" (p. 63). Areas for display need to be broken down into two broad categories: non-projection and projection (Moscoe) to provide venues for a variety of student work.

Facility designers need to consider a variety of factors when choosing furnishings and task surfaces, to provide a flexible instructional environment (Simmons, 1995). A consideration was that properly designed furniture will promote the health of teachers, students, and staff. "Ergonomics is an umbrella term that covers the necessity of designing and providing the best possible environment that supports and nourishes human beings' changing needs" (Simmons, 1995, p. 79). Emphasis on students working in teams has prompted school designers to build spaces that promote cooperative work and teaming (NASBE, 1996). However, in high-tech high schools much time will be spent at computers, therefore, according to Simmons (1995) some work station criteria include: (a) work surface height adjustable from 26 - 34 in, (b) minimum leg clearance (from chair to front surface of desk) 26 in, (c) minimum thigh clearance 8 in (seat of chair to bottom of work surface), (d) computer monitor height (midpoint of monitor) adjustable from 36 to 43 in, and (e) keyboard height adjustable from 22 to 28 in (p. 80).

Ergonomic furniture both fits the mental and visual image of a high-tech high school, in addition it encourages group work. Flexible seating allowed and fostered group work and enhanced interaction and productivity (Simmons, 1995). Crumpacker (1995) stated, "A healthy culture depends on its members' ability to plan together informally . . . why not make them inviting, easy to reach, and comfortable" (p. 41). "Such areas should have few visual boundaries and be centrally located, easily accessible, and on major traffic routes for all building users" (Crumpacker, 1995, p. 41).

Summary

The link between student achievement and facility design was established through the literature. Earthman (2004) has conducted research in the area of the effect of facility design on student achievement and directed many studies of doctoral students researching this connection. However, little conclusive research showed the link between integrating technology throughout an educational facility and increased student success. However, Earthman stated that even if only a small portion of variation in outcome results from the physical environment, it was a portion of the variance that can then be controlled through efforts of educators and design professionals. In technology-rich high schools anecdotal comments such as the one reported by Shorr (2004) sum the benefits, by stating, "Students are spending extra hours on subjects outside of the classroom" and achieving at higher levels" (p.26).

CHAPTER 3

Methodology

This chapter specifies the procedures that were used to gather and analyze data to answer the research question. The subsequent sections include the purpose of the study, the research question, the research design, the instrument design, building, population, sample, and data collection.

Purpose of Study

The purpose of this study was to determine the essential facility components when designing and building an educational facility dedicated to the pursuit of technological programs of study. The research question was derived from a void in the research or practical literature providing school- or district-level administrators a guide in the planning for and creation of a facility specifically devoted to instruction in high-end technology programs.

Research Question

The research question was as follows:

What are the essential elements in a facility providing specialized instruction in technology-emphasized programs of study for high school facilities--as indicated by CIOs and local school technology coordinators/technicians--as demonstrated through this study.

Null hypothesis 1 - There was no statistical difference between the essential facility components in the area of school organization between the two sample groups.

Null hypothesis 2 - There was no statistical difference between the essential facility components in the area of instructional spaces between the two sample groups.

Null hypothesis 3 - There was no statistical difference between the essential facility components in the area of instructional tools between the two sample groups.

Null hypothesis 4 - There was no statistical difference between the essential facility components in the area of technology infrastructure between the two sample groups.

Null hypothesis 5 - There was no statistical difference between the essential facility components in the area of common areas, furniture and decor between the two sample groups.

Null hypothesis 6 - There was no statistical difference in the rank order of the absolute essential elements between the two groups.

Research Design

This study was concerned with gathering responses from school district chief information officers and local school based technology coordinators, identifying the most essential components necessary in a high-tech high school facility. A Survey Instrument (Appendix A) was sent to two sample respondent pools, with a purpose to determine how closely the two respondent pools were in agreement on essential facility components in each pool.

Instrument Design

Through the literature review, a series of essential components, organized into five categories that may be included in a specialized facility focusing on technology instruction was complied. The categories were: School Organization; Instructional Spaces, Instructional Tools, Technology Infrastructure, and Common Areas, Furniture and Décor. A Survey Instrument of facility components was created to solicit opinions from the two sample pools.

Population and Sample

The study population consisted of two sample groups. Group A was identified as chief information officers (CIO) in school districts who have built a facility housing a specialized-technology high school or program including CIOs of the National Consortium of Specialized Secondary Schools of Math, Science, and Technology schools and the National Academy Foundation. At the time of the study The National Consortium of Specialized Secondary Schools of Math, Science, and Technology group consisted of 42 members and the membership list was available at www.nasssmst.org. The National Academy Foundation membership was approximately 150 schools with 96 districts with information technology academies. Group B was the local school based technology coordinators assigned to the same schools identified for Group A. An anticipated return rate for the Survey Instrument was 25% and an adequate sample size for the study.

Data Analysis

The respondents answered each question on the Survey Instrument, using a 4-point scale. Responses to the items were given on the following scale: 1 = absolutely essential, 2 = essential, 3 = slightly essential, 4 = not essential. The Survey Instrument had two analyses of the responses. Those are described as follows:

1. Components are ranked ordered within each respondents group.
2. The two ranked lists of responses will be compared using the Mann-Whitney analysis to determine the correlation of responses between the two sample groups.

Mann-Whitney tests helped the researcher determine the extent of disagreements in the rankings between the two groups and to determine the correlation of responses between the two sample groups. An analysis of the data showing significance addressed the research question and the data shall be reported and analyzed in Chapter 4 of this study, with implications of the study outlined in Chapter 5.

For this study, significance testing will be performed based on $\alpha = .05$. However, due to the exploratory natures of this study, findings significant at $\alpha = .10$ will be noted to suggest trends for future research.

Summary

The purpose of this chapter was to describe the methodology used to gather and prepare the data for analysis. The participants consisted of school district chief information officers of National Association of Specialized Secondary Schools of Math, Science, and Technology (NASSSMST) schools and National Academy Foundation schools. Surveys were sent via an Internet based survey program. It was projected that the Survey Instrument would take 20 minutes to complete. Respondents were encouraged to complete the survey through encouragement via follow-up emails. A data analysis of the responses was conducted with results described in Chapter 4 of this study and implications described in Chapter 5.

CHAPTER 4

Results

The purpose of the study was (a) to develop a list of facility design components considered essential by chief information officers of local school districts and the local school technology coordinators/technicians in designing a high school facility focusing on technology programs of study and (b) to determine if the two groups agree on essential elements of school design. The resulting list served as a resource for school/district administrators looking for a starting point when faced with designing a high-tech high school. Fifty-one school based tech coordinators and twenty-seven districts Chief Information Officers (CIO) participated in this study.

Table 1 displays the Mann-Whitney test comparisons between the two groups of educators for the nine school organization questions. Significant differences were found between the two groups for seven of nine questions. For five of those differences, school based tech coordinators rated the question as more essential. School district chief information officers rated two questions as more essential: Question 1D, “Shared school facilities with post secondary (p = .004)” and Question 1J, “Smart cards to manage student accounts (p = .030)” (Table 1).

Table 2 displays the Mann-Whitney test comparisons between the two groups of educators for the 10 instructional spaces questions. School based tech coordinators rated two questions as significantly more essential: Question 2D, “Laptop plug-ins stations in classrooms (p = .080)” and Question 2F, “Minimum of one electrical outlet per student (p = .090)” (Table 2).

Table 3 displays the Mann-Whitney test comparisons between the two groups of

Table 1
Comparison of School Organization Opinions Based on Type of Educator. Mann-Whitney Tests (N = 78)

	Type a	M b	SD	z	p
Q1A School enrollment should not exceed 1,000	SBTC	1.69	0.91	5.02	.001
	CIO	2.93	0.83		
Q1B School should be organized into career/learning academies	SBTC	2.08	1.04	1.02	.308
	CIO	2.30	0.99		
Q1C No more than 25 students per class	SBTC	1.65	0.74	2.41	.016
	CIO	2.07	0.78		
Q1D Shared school facilities with post secondary	SBTC	2.63	1.11	2.85	.004
	CIO	1.89	0.70		
Q1E Longer school day	SBTC	1.88	0.89	3.96	.001
	CIO	2.78	0.85		
Q1F Industry standard curriculum	SBTC	1.90	0.85	3.31	.001
	CIO	2.59	0.84		
Q1G Comprehensive high school curriculum	SBTC	1.71	0.73	1.94	.052
	CIO	2.04	0.71		
Q1H Rooms design of 1,200+ square feet	SBTC	1.73	0.83	.010	.995
	CIO	1.70	0.78		
Q1I Smart cards to manage student accounts	SBTC	2.71	1.15	2.18	.030
	CIO	2.11	0.85		

[a] Type: SBTC = *School Based Technology Coordinators (n* = 51) CIO = *School District Chief Information Officer* (*n* = 27)
[b] Opinion Scale: 1 = *Absolutely essential* to 4 = *Not essential*

Table 2

*Comparison of Instructional Spaces Opinions Based on Type of Educator. Mann-Whitney Tests (*N *= 78)*

	Type [a]	*M* [b]	*SD*	*z*	*p*
Q2A Flexible instructional space	SBTC	1.90	0.90	1.18	.237
	CIO	1.67	0.83		
Q2B Integrated/cross curriculum learning spaces	SBTC	1.80	0.63	0.30	.762
	CIO	1.93	0.87		
Q2C Dimmer light switches	SBTC	2.57	1.10	0.91	.363
	CIO	2.33	1.11		
Q2D Laptop plug-ins stations in classrooms	SBTC	1.76	0.74	1.75	.080
	CIO	2.22	1.09		
Q2E Interactive wireless white boards and teacher podiums	SBTC	1.96	0.92	0.68	.494
	CIO	2.07	0.87		
Q2F Minimum one electrical outlet per student	SBTC	1.88	0.79	1.69	.090
	CIO	2.30	1.03		
Q2G Universally accessible space and equipment	SBTC	1.15	0.70	0.71	.479
	CIO	1.37	0.56		
Q2H Dedicated and equipped TV production space and editing equipment	SBTC	2.22	1.03	0.25	.801
	CIO	2.22	0.89		
Q2I Lecture/meeting hall with professional, conference grade technology	SBTC	2.04	0.94	0.18	.855
	CIO	2.00	0.96		
Q2J Professional teacher work rooms with network connections, telecommunications, etc.	SBTC	1.75	0.82	1.26	.206
	CIO	2.04	0.98		

[a] Type: SBTC = *School Based Technology Coordinators* (n = 51) CIO = *School Districts Chief Information Officer* (n = 27)
[b] Opinion Scale: 1 = *Absolutely essential* to 4 = *Not essential*

educators for the 10 instructional tools questions. School based tech coordinators rated two questions as significantly more essential: Question 3A, "Video projectors in all classrooms (p = .010)" and Question 3B, "Electronic or web based textbooks ($p = .008$)" (Table 3).

Table 4 displays the Mann-Whitney test comparisons between the two groups of educators for the 16 technology infrastructure questions. For all six significant differences, the school based tech coordinators rated the question as more essential (Table 4).

Table 5 displays the Mann-Whitney test comparisons between the two groups of educators for the eight common areas questions. School based tech coordinators rated two questions as significantly more essential: Question 5A, "Fully wired media/meeting center to support instruction and professional learning (p = .029)" and Question 5E, "Daylighting to balance lighting levels (p = .049)" (Table 5).

Table 6 displays the psychometric characteristics for the five derived scales and the total scale score. The total scale score included all 53 questions and had a reliability coefficient of $r = .95$. All Cronbach reliability coefficients were at least $r = .70$ suggesting adequate reliability. The category rated most essential was "technology infrastructure ($M = 1.71$)" and the least essential was "common areas, furniture, and doors ($M = 2.21$)" (Table 6).

Table 7 displays the Mann-Whitney test comparisons between the two groups of educators for the six scales. School based tech coordinators rated 4 of 6 scales as significantly more essential (Table 7).

Table 8 displays the opinion ratings for the 51 school based tech coordinators for the 53 questions. These ratings were based on a four-point scale (1 = Absolutely essential to 4 = Not essential). Questions rated most essential were Question 4B, "Schools interoperability framework (M = 1.47)" and Question 2G, "Universally accessible space and equipment (M =

Table 3
Comparison of Instructional Tools Opinions Based on Type of Educator. Mann-Whitney Tests (N = 78)

	Type a	M b	SD	z	p
Q3A Video projectors in all classrooms	SBTC	1.57	0.85	2.57	.010
	CIO	2.11	0.97		
Q3B Electronic or web based textbooks	SBTC	1.82	0.87	2.65	.008
	CIO	2.41	0.93		
Q3C Handheld computing devices for students	SBTC	2.51	1.17	0.33	.740
	CIO	2.59	1.01		
Q3D Online or Web-assisted learning options	SBTC	1.86	0.75	0.92	.360
	CIO	2.07	0.92		
Q3E Laptop screen capture/control software	SBTC	1.98	0.88	1.04	.296
	CIO	2.19	0.92		
Q3F More than average money and time for professional development/training	SBTC	1.63	0.63	1.18	.240
	CIO	1.81	0.68		
Q3G Laptops or tablets for all staff and students	SBTC	1.98	1.03	0.91	.362
	CIO	2.19	1.04		
Q3H Datacasting capabilities	SBTC	2.20	0.85	0.32	.758
	CIO	2.22	0.80		
Q3I Student Internet mail addresses hosted in-house	SBTC	2.12	0.99	1.59	.112
	CIO	2.48	1.01		
Q3J Portable storage devices (iPod)	SBTC	2.51	1.19	1.13	.258
	CIO	2.81	0.88		

[a] Type: SBTC = *School Based Technology Coordinator (n* = 51) CIO = *School District Chief Information Officer (n* = 27)
[b] Opinion Scale: 1 = *Absolutely essential* to 4 = *Not essential*

Table 4

Comparison of Technology Infrastructure Opinions Based on Type of Educator. Mann-Whitney Tests (N = 78)

	Type a	M b	SD	z	p
Q4A Roving wireless security protocol	SBTC	1.75	0.69	0.44	.658
	CIO	1.70	0.78		
Q4B Schools interoperability framework	SBTC	1.47	0.58	0.40	.687
	CIO	1.56	0.70		
Q4C Multiple firewalls and most up-to-date secure network affordable	SBTC	1.65	0.66	0.49	.623
	CIO	1.56	0.58		
Q4D IP voice and video system	SBTC	1.73	0.75	0.95	.341
	CIO	1.93	0.87		
Q4E Easily accessible, exposed wiring/cabling	SBTC	1.57	0.61	1.83	.067
	CIO	1.85	0.66		
Q4F Computer controlled/monitored HVAC	SBTC	1.69	0.71	2.30	.021
	CIO	2.04	0.65		
Q4G Web accessible security cameras	SBTC	1.71	0.73	2.23	0.26
	CIO	2.11	0.80		
Q4H "Better than average" AC systems	SBTC	1.51	0.58	2.09	.026
	CIO	1.81	0.62		
Q4I "Better than average" campus electrical systems	SBTC	1.69	0.76	0.45	.651
	CIO	1.74	0.71		

Table 4 Continued

Table 4 Continued

	Type a	M b	SD	z	p
Q4J Network remote access and self-monitoring file servers	SBTC	1.71	0.73	0.01	.995
	CIO	1.70	0.72		
Q4K Fiber optic cabling	SBTC	1.65	0.74	0.28	.777
	CIO	1.63	0.56		
Q4L Wireless environment	SBTC	1.69	0.73	0.04	.967
	CIO	1.70	0.78		
Q4M Centralized head-end room	SBTC	1.61	0.60	1.48	.140
	CIO	1.93	0.87		
Q4N Broadband access 24/7	SBTC	1.51	0.70	0.88	.381
	CIO	1.70	0.87		
Q4O High quality cyber security system	SBTC	1.67	0.65	1.64	.100
	CIO	1.96	0.81		
Q4P Programmable phone systems	SBTC	1.82	0.87	2.68	.007
	CIO	2.44	1.01		

[a] Type: SBTC = *School Based Technology Coordinator (n = 51) CIO = School District Chief Information Officer (n = 27)*
[b] Opinion Scale: 1 = *Absolutely essential* to 4 = *Not essential*

Table 5

*Comparison of Common Areas, Furniture, and Door Opinions Based on Type of Educator. Mann-Whitney Tests (*N *= 78)*

	Type [a]	*M* [b]	*SD*	*z*	*p*
Q5A Fully wired media/meeting center to support instruction and professional learning	SBTC	1.61	0.80	2.18	.029
	CIO	2.04	0.90		
Q5B Digital monitors to display student work in common areas and media center	SBTC	2.41	1.10	0.38	.702
	CIO	2.26	0.90		
Q5C Ergonomically correct furniture	SBTC	2.45	1.12	0.97	.333
	CIO	2.19	0.92		
Q5D Flat-top computer tables	SBTC	2.06	1.05	0.54	.591
	CIO	2.11	0.85		
Q5E Daylighting to balance lighting levels	SBTC	1.84	0.83	1.97	.049
	CIO	2.22	0.85		
Q5F Group work tables/stations and meeting areas	SBTC	2.16	0.92	0.46	.646
Q5G "High tech" looking architecture, entrance, and furniture	SBTC	2.57	1.12	0.59	.553
	CIO	2.74	0.94		
Q5H Centralized graphics/production lab for various instructional programs	SBTC	2.35	1.13	0.72	.470
	CIO	2.52	0.94		

[a] Type: SBTC = *School Based Technology Coordinator* (*n* = 51) CIO = *School District Chief Information Officer* (*n* = 27)

[b] Opinion Scale: 1 = *Absolutely essential* to 4 = *Not essential*

Table 6

*Psychometric Characteristics for Derived Scales (*N *= 78)*

	Number of items	*M* [a]	*SD*	Low	High	Alpha
School organization	9	2.09	0.53	1.00	3.33	.73
Instructional spaces	10	1.97	0.56	1.00	3.20	.82
Instructional tools	10	2.11	0.64	1.00	3.20	.87
Technology						
Infrastructure	16	1.71	0.46	1.00	3.00	.90
Common areas, furniture, and door	8	2.21	0.75	1.00	4.00	.90
Total score	53	1.98	0.45	1.00	3.00	.95

[a] Opinion Scale: 1 = *Absolutely essential* to 4 = *Not essential*

Table 7

Comparison of Derived Scales Based on Type of Educator. Mann-Whitney Tests (N = 78)

	Type a	M b	SD	z	p
School organization	SBTC	2.00	0.56	2.27	.023
	CIO	2.27	0.43		
Instructional spaces	SBTC	1.94	0.58	0.51	.610
	CIO	2.01	0.51		
Instructional tools	SBTC	2.02	0.64	1.87	.062
	CIO	2.29	0.61		
Technology infrastructure	SBTC	1.65	0.48	1.86	.063
	CIO	1.84	0.40		
Common areas, furniture, and door	SBTC	2.18	0.78	0.50	.617
	CIO	2.26	0.70		
Total Score	SBTC	1.91	0.48	2.14	.033
	CIO	2.09	0.37		

[a] Type: SBTC = *School Based Technology Coordinator (n* = 51) CIO = *School District Chief Information Officer (n* = 27)
[b] Opinion Scale: 1 = *Absolutely essential* to 4 = *Not essential*

1.51)." The technology infrastructure category had 5 of the top 10 most essential rated items (Table 8).

Table 9 displays the opinion ratings for the 27 school based tech coordinators for the 53 questions. Questions rated most essential were Question 2G, "Universally accessible space and equipment (*M* = 1.37)" and Question 4C, "Multiple firewalls and the most up-to-date security network affordable (*M* = 1.56)." The technology infrastructure category had 7 of the top 10 most essential rated items (Table 9).

Table 8

Opinion Ratings for School Based Tech Coordinators Only. Sorted by Most Essential a (N = 51)

Opinion	Category b	M	SD
Q4B Schools interoperability framework	Tech infra	1.47	0.58
Q2G Universally accessible space and equipment	Instr space	1.51	0.70
Q4H "Better than average" AC systems	Tech infra	1.51	0.58
Q4N Broadband access 24/7	Tech infra	1.51	0.70
Q3A Video projectors in all classrooms	Instr tools	1.57	0.85
Q4E Easily accessible, exposed wiring/cabling	Tech infra	1.57	0.61
Q5A Fully wired media/meeting center to support instruction and professional learning	Comm areas	1.61	0.80
Q4M Centralized head-end room	Tech infra	1.61	0.60
Q3F More than average money and time for professional development/training	Instr tools	1.63	0.63
Q1C No more than 25 students per class	Sch Org	1.65	0.74
Q4C Multiple firewalls and most up-to-date secure network affordable	Tech Infra	1.65	0.66
Q4K Fiber optic cabling	Tech Infra	1.65	0.74
Q4O High quality cyber security system	Tech Infra	1.67	0.65
Q4F Computer-controlled/-monitored HVAC	Tech Infra	1.69	0.71
Q4I "Better than average" campus electrical systems	Tech Infra	1.69	0.76
Q4L Wireless environment	Tech Infra	1.69	0.73
Q1A School enrollment should not exceed 1,000	Sch Org	1.69	0.91
Q4G Web-accessible security cameras	Tech Infra	1.71	0.73

Table 8 Continued

Table 8 Continued

Opinion	Category b	M	SD
Q4J Network remote access and self-monitoring file servers	Tech Infra	1.71	0.73
Q1G Comprehensive high school curriculum	Sch org	1.71	0.73
Q4D IP voice and video system	Tech infra	1.73	0.75
Q1H Rooms design of 1,200 + sq ft	Sch org	1.73	0.83
Q2J Professional teacher work rooms with Instr network connections, telecommunications, space etc.	1.75	0.82	
Q4A Roving wireless security protocol	Tech infra	1.75	0.69
Q2D Laptop plug-ins stations in classrooms	Instr space	1.76	0.74
Q2B Integrated/cross curriculum learning spaces	Instr space	1.80	0.63
Q3B Electronic or Web-based textbooks	Instr tools	1.82	0.87
Q4P Programmable phone systems	Tech infra	1.82	0.87
Q5E Daylighting to balance lighting levels	Comm areas	1.84	0.83
Q3D Online or Web-assisted learning options	Instr tools	1.86	0.75
Q1E Longer school day	Sch org	1.88	0.89
Q2F Minimum one electrical outlet per student	Instr space	1.88	0.79
Q2A Flexible instructional space	Instr space	1.90	0.90
Q1F Industry-standard curriculum	Sch org	1.90	0.85
Q2E Interactive, wireless white boards and teacher podiums	Instr space	1.96	0.92
Q3G Laptops or tablets for all staff and students	Instr tools	1.98	1.03
Q3E Laptop screen capture/control software	Instr tools	1.98	0.88
Q2I Lecture/meeting hall with professional, conference grade technology	Instr space	2.04	0.94
Q5D Flat-top computer tables	Comm areas	2.06	1.05

Table 8 Continued

Table 8 Continued

Opinion	Category b	M	SD
Q1B School should be organized into career/learning academies	Sch org	2.08	1.04
Q3I Student Internet mail addresses hosted in-house	Instr tools	2.12	0.99
Q5F Group work tables/stations and meeting areas	Comm areas	2.16	0.92
Q3H Datacasting capabilities	Instr tools	2.20	0.85
Q2H Dedicated and equipped TV production space and editing equipment	Instr space	2.22	1.03
Q5H Centralized graphics/production lab for various instructional programs	Comm areas	2.35	1.13
Q5B Digital monitors to display student work in common areas and media center	Comm areas	2.41	1.10
Q5C Ergonomically correct furniture	Comm areas	2.45	1.12
Q3J Portable storage devices (iPod)	Instr tools	2.51	1.19
Q3C Handheld computing devices for students	Instr tools	2.51	1.17
Q2C Dimmer light switches	Instr space	2.57	1.10
Q5G "High-tech" looking architecture, entrance, and furniture	Comm areas	2.57	1.12
Q1D Shared school facilities with post secondary	Sch org	2.63	1.11
Q1I Smart cards to manage student accounts	Sch org	2.71	1.15

[a] Opinion Scale: 1 = *Absolutely essential* to 4 = *Not essential*
[b] Category: Sch Org = *School Organization*; Instr Space = *Instructional Spaces*; Instr Tools = *Instructional Tools*; Tech Infra = *Technology Infrastructure*; Comm Areas = *Common Areas, Furniture, and Door*

Table 9
Opinion Ratings for District Chief Information Officers Only.
Sorted by Most Essential a (N = 27)

Opinion	Category b	M	SD
Q2G Universally accessible space and equipment	Instr space	1.37	0.56
Q4C Multiple firewalls and most up-to-date secure network affordable	Tech infra	1.56	0.58
Q4B Schools interoperability Framework	Tech infra	1.56	0.70
Q4K Fiber optic cabling	Tech infra	1.63	0.56
Q2A Flexible instructional space	Instr space	1.67	0.83
Q1H Rooms design of 1,200 + sq ft	Sch org	1.70	0.78
Q4L Wireless environment	Tech infra	1.70	0.78
Q4N Broadband access 24/7	Tech infra	1.70	0.87
Q4A Roving wireless security protocol	Tech infra	1.70	0.78
Q4J Network remote access and self-monitoring file servers	Tech infra	1.70	0.72
Q4I "Better than average" campus electrical systems	Tech infra	1.74	0.71
Q3F More than average money and time for professional development/training	Instr tools	1.81	0.68
Q4H "Better than average" AC systems	Tech infra	1.81	0.62
Q4E Easily accessible, exposed wiring/cabling	Tech infra	1.85	0.66
Q1D Shared school facilities with post secondary	Sch org	1.89	0.70
Q2B Integrated/cross curriculum learning spaces	Instr space	1.93	0.87
Q4D IP voice and video system	Tech infra	1.93	0.87

Table 9 Continued

Table 9 Continued

Opinion	Category b	M	SD
Q4M Centralized head-end room	Tech infra	1.93	0.87
Q4O High quality cyber security system	Tech infra	1.96	0.81
Q2I Lecture/meeting hall with professional, conference grade technology	Instr space	2.00	0.96
Q1G Comprehensive high school curriculum	Sch org	2.04	0.71
Q4F Computer-controlled/-monitored HVAC	Tech infra	2.04	0.65
Q5F Group work tables/stations and meeting areas	Comm areas	2.04	0.90
Q2J Professional teacher work rooms with network connections, telecommunications, etc.	Instr space	2.04	0.98
Q5A Fully wired media/meeting center to support instruction and professional learning	Comm areas	2.04	0.90
Q1C No more than 25 students per class	Sch org	2.07	0.78
Q3D Online or Web-assisted learning options	Instr tools	2.07	0.92
Q2E Interactive, wireless white boards and teacher podiums	Instr space	2.07	0.87
Q1I Smart cards to manage student accounts	Sch org	2.11	0.85
Q3A Video projectors in all classrooms	Instr tools	2.11	0.97
Q4G Web accessible security cameras	Tech infra	2.11	0.80
Q5D Flat top computer tables	Comm areas	2.11	0.85
Q3G Laptops or tablets for all staff and students	Instr tools	2.19	1.04
Q5C Ergonomically correct furniture	Comm areas	2.19	0.92

Table 9 Continued

Table 9 Continued

Opinion	Category b	M	SD
Q3E Laptop screen capture/control software	Instr tools	2.19	0.92
Q2D Laptop plug-ins stations in classrooms	Instr space	2.22	1.09
Q3H Datacasting capabilities	Instr tools	2.22	0.80
Q2H Dedicated and equipped TV production space and editing equipment	Instr space	2.22	0.89
Q5E Daylighting to balance lighting levels	Comm areas	2.22	0.85
Q5B Digital monitors to display student work in common areas and media center	Comm areas	2.26	0.90
Q1B School should be organized into career/learning academies	Sch org	2.30	0.99
Q2F Minimum one electrical outlet per student	Instr space	2.30	1.03
Q2C Dimmer light switches	Instr space	2.33	1.11
Q3B Electronic or Web-based textbooks	Instr tools	2.41	0.93
Q4P Programmable phone systems	Tech infra	2.44	1.01
Q3I Student Internet mail addresses hosted in-house	Instr tools	2.48	1.01
Q5H Centralized graphics/production lab for various instructional programs	Comm areas	2.52	0.94
Q1F Industry-standard curriculum	Sch org	2.59	0.84
Q3C Handheld computing devices for students	Instr tools	2.59	1.01

Table 9 Continued

Table 9 Continued

Opinion	Category b	M	SD
Q5G "High-tech" looking architecture, entrance, and furniture	Comm areas	2.74	0.94
Q1E Longer school day	Sch org	2.78	0.85
Q3J Portable storage devices (iPod)	Instr tools	2.81	0.88
Q1A School enrollment should not exceed 1,000	Sch org	2.93	0.83

[a] Opinion Scale: 1 = *Absolutely essential* to 4 = *Not essential*
[b] Category: Sch Org = *School Organization*; Instr Space = *Instructional Spaces*; Instr tools = *Instructional Tools*; Tech Infra = *Technology Infrastructure*; Comm Areas = *Common Areas, Furniture, and Door*

CHAPTER 5

Conclusions

The purpose of the study was (a) to develop a list of facility design components considered essential by chief information officers of local school districts and the local school technology coordinators/technicians to design a high school facility focusing on technology programs of study and (b) to determine if the two groups agree on essential elements of school design. The resulting list can serve as a resource for school/district administrators looking for a starting point when faced with designing a high-tech high school. Five different categories of questions were identified from the literature that constituted the basis for the survey questions sent to the two respondent pools. The questions were grouped into categories of similar questions labeled School, Organization, Instructional Spaces, Instructional Tools, Technology Infrastructure, and Common Areas and Furniture.

The findings indicated the most essential components for both groups were in the category of Technology Infrastructure, with the respondents in general seeing the questions across all categories in a similar vein. The respondents either considered the components essential or not essential to be included into the design of a high-tech high school. Across all five categories school based technology coordinators found many components more necessary than school district chief information officers, with two of the top three components being aligned between the two groups. For school based tech coordinators, the technology infrastructure category had 5 of the top 10 most essential rated items, with school interoperability framework ranked as the number one component to be included from the list. CIOs responded that universally accessible space and equipment are the most essential component. This group indicated the technology infrastructure category had 7 of the top 10 most essential rated items.

Thirteen components (Q1A, Q1C, Q1E, Q1F,Q1I, Q3A, Q3B, Q4F, Q4H, Q4P, Q5A, and Q5E) across four of the five categories showed statistical significance less than the .05 level indicating agreements between the two sample groups of the necessity of including particular elements in the design of the high tech facility. As indicated from these results, state and or school district facility designers should take particular notice of these items for inclusion in a high tech high school design.

Literature and research study findings are inadequate in this area of developing a blue print or school-wide guide to what components should be included in a high-tech high school. Comments are often included anecdotally in articles and research papers, with individual components having some scientific study references; but as a whole no comprehensive plan or study has noted the depth or breadth of components included in this study. Therefore, those few references to the topic of this study include comments to help subsequent individuals undergoing this process such as: "We know that despite the success of a committee structure, one organization must take responsibility for leading and managing the process" (Boettcher & Morrow, 1995, p.139). Because previous research was used to compile the survey for this study, all components included have references in chapter 2 to their validity for inclusion (see Appendix B). The study did not reveal that any of those components should not have been included per the respondents' opinions. No components were rejected outright by this study's survey results and no additional components were suggested to be essential for inclusion. The rank ordering of the results were not directly related to the number of references cited in this study per component. This study is not a meta-analysis of all research done per component, but rather an analysis of the components identified and their relationship to inclusion in a plan for a high-tech high school and the opinion of their worthiness as measured by districts versus school level personnel. The link between student achievement and facility design is established.

Earthman (2004) has conducted research in the area of the effect of facility design on student achievement and directed many studies of doctoral students researching this connection. However, little conclusive research has shown the link between integrating technology throughout an educational facility and increased student success. However, Earthman argues that even if there is only a small portion of variation in outcome results from the physical environment, it is a portion of the variance that can then be controlled through efforts of educators and design professionals. Both respondent pools in this study may or may not agree with that statement, as the focus of the survey was technology. However, of the physical components and building design components listed, universal accessibility was in the top three components for both groups.

Future research questions should include new innovations in technology that could be included as components in a high-tech high school. Respondents to this study did not indicate what additional components should be included, but that is certainly a flaw with the results, as technology is constantly changing and new innovations may have been developed since the conception of this study.

This study could be improved by creating a wider differential scale for respondents to rank the need of the components. The findings indicated respondents tended to answer similarly across all questions, so a broader range of ranking options would create a better differential between the components.

The study validated the researcher's belief in the disconnect between what the decision makers who are at the district level believe are essential components to be included in a high-tech high school and what the building-level practitioners responsible for deployment and operation believe are essential components (Table 7). This could be reflective of a personal proclivity by local school based technology coordinators working with students to use technology or could be colored by their working relationships with teachers and students utilizing the technology in the local school.

State departments of education should create lists of essential components, as seen from their own local surveys of district and school-based personnel. Considering the variety of educational focuses from school to school, district to district, and state to state, potential lists of essential components, as derived from local representatives, would have more validity. In addition, funding options could be correlated with the list so that districts would be aware of potential funding sources and not have decisions driven solely by economic and funding considerations.

Local districts and schools need to assess the local users of the technology when deciding what technology components to include in a facility considered a high-tech high, as well as referring to the state guidelines for such a facility. If local districts had the knowledge of what components deemed essential they would have a basis to begin their own evaluation process of essential components. In addition, the state could provide funds for those components or direct the district to grants or other potential funding sources.

The purpose of the study is (a) to develop a list of facility design components as considered essential by chief information officers of local school districts and the local school technology coordinators/technicians to designing a high school facility focusing on technology programs of study and (b) to determine if the two groups agree on essential elements of school design. The resulting list will serve as a resource for school/district administrators looking for a starting point when faced with designing a high-tech high school that could be adopted by states and/or national standards decision makers.

Without state or national standards of the essential technology components that should be included in a high-tech high school, local educational professionals make decisions without adequate knowledge of tested, reliable, sustainable, or financially supported equipment or services that may be available.

Research on individual components or the effect of the physical educational environment of student achievement has been researched and documented. However, there is an absence of research studies that indicate which technology component(s) should be considered essential to building a learning environment, based on their effectiveness in positively affecting student achievement.

This study found that all technology components gleaned from the literature were considered essential and that the district-level people making the decisions about including this technology in a building and those responsible for its deployment, integration, and operation varied significantly. Though both groups ranked some components essential, they disagreed across the categories enough to have a statistical difference (Table 6). This resulting difference is enough to behoove state and/or national policy makers to adopt state or national standards covering the minimal essential components to purchase and take the subjectivity of the decision makers' opinions out of the design process.

This study can used to influence state policy makers to adopt benchmark standards for technology to be included in all classrooms--thus, creating a minimal standard to which all schools of this specialized nature must adhere. Nothing could prevent schools and or districts from exceeding the minimal standard and employing more technology into their high-tech high schools. However, there should be a similar study analyzing the attitudes and opinions between district-level decisions and purchasing and those with accountability for deployment and integration.

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APPENDIX A
SURVEY INSTRUMENT

SURVEY OF ESSENTIAL FACILITY COMPONENTS WHEN DESIGNING A SPECIALIZED HIGH SCHOOL TECHNOLOGY FOCUSED PROGRAM

Directions for completing survey

Drawing from your expertise, place a check mark in the appropriate category giving your opinion of importance for each facility component to designing and building a high-tech-high school. Please mark only one column per component. A space is provided at the end for you to include any component you feel has been forgotten.

CATEGORY 1 SCHOOL ORGANIZATION (School size, time and class schedule)	Absolutely Essential	Essential	Slightly Essential	Not Essential
1A. School enrollment should not exceed 1000				
1B. School should be organized into career/learning academies				
1C. No more than 25 students per class				
1D. Shared school facilities with post secondary				
1E. Longer school day				
1F. Industry standard curriculum				
1G. Comprehensive high school curriculum				
1H. Rooms design of 1200+ square feet				
1I. Smart cards to manage student accounts				

CATEGORY 2 INSTRUCTIONAL SPACES (Teaching and learning facility space)	Absolutely Essential	Essential	Slightly Essential	Not Essential
2A. Flexible instructional space				
2B. Integrated/cross curriculum learning spaces				
2C. Dimmer light switches				
2D. Laptop plug-ins stations in classrooms				
2E. Interactive, wireless white boards & teacher podiums				
2F. Minimum one electrical outlet per student				
2G. ADA accessible space & equipment				
2H. Dedicated & equipped TV production				

space and editing equipment				
2I. Lecture/meeting hall with professional, conference grade technology				
2J. Professional teacher work rooms with network connections, telecommunications, etc.				

CATEGORY 3 - INSTRUCTIONAL TOOLS (Teaching and learning tools for all spaces)	Absolutely Essential	Essential	Slightly Essential	Not Essential
3A. Video projectors in all classrooms				
3B. Electronic or web based textbooks				
3C. Handheld computing devices for students				
3D. Online or web assisted learning options				
3E. Laptop screen capture/control software				
3F. More than average money and time for professional development/training				
3G. Laptops or tablets for all staff & students				
3H Datacasting capabilities				
3I. Student Internet mail addresses hosted in-house				
3J Portable storage devices (iPod)				
3K Digital assessments and essay graders				

CATEGORY 4 – TECHNOLOGY INFRASTRUCTURE (IT hardware, software, protocols, configurations)	Absolutely Essential	Essential	Slightly Essential	Not Essential
4A. Roving wireless security protocol				
4B. Schools Interoperability Framework				
4C. Multiple firewalls and most up-to-date secure network affordable				
4D. IP voice and video system				
4E. Easily accessible, exposed wiring/cabling				
4F. Computer controlled/monitored HVAC				
4G Web accessible security cameras				
4H. "Better than average" AC systems				
4I. "Better than average" campus electrical system				
4J Network remote access & self monitoring file servers				
4K. Fiber optic cabling				

4L Wireless environment				
4M Centralized head-end room				
4N Broadband access 24/7				
4O High quality cyber security system				
4P Programmable phone systems				

CATEGORY 5 - COMMON AREAS, FURNITURE, AND DÉCOR (General, all purpose areas of facility, furniture & decoration)	Absolutely Essential	Essential	Slightly Essential	Not Essential
5A Fully wired media center				
5B Digital monitors to display student work in common areas & Media Center				
5C Ergonomically correct furniture				
5D Flat top computer tables				
5E Daylighting to balance lighting levels				
5F Group work tables/stations & meeting areas				
5G "High tech" looking architecture, entrance & furniture				
5H Centralized graphics/production lab for various instructional programs				

Feel free to write in any additional components and check mark the column ranking its importance.

ADDITIONAL COMPONENTS	Absolutely Essential	Essential	Slightly Essential	Not Essential

APPENDIX B
CHARTS OF REFERENCES BY CATEGORY

Category 1

CITATIONS	SCHOOL SIZE AND ORGANIZATION								
	1A	1B	1C	1D	1E	1F	1G	1H	1I
Berner, 1995, p. 86	●								
Bingler, 1995, p. 28				●					
Cotton, 1996, p.	●								
Custhall, 2003, p. 20						●			
Custhall, 2003, p. 22		●							
Cutshall, 2002, p. 61								●	
Fielding, 1999, p. 2								●	
Fiske, 1995, p. 7.	●								
Gewertz, 2001, p. 2	●								
Hardt, 1998, p. 57			●						
Kennedy, 2001, p. 3	●								
Kennedy, 2001, p. 4		●							
Lyons, 2001, p. 7,	●	●	●		●				
Moore & Lackney, 1995, p. 13,15, 17,	●	●							
Murray, 2005, p. 32									●
NASBE, 1996, p. 15, 11, 7,7	●			●	●			●	
Nathan & Febey, 2001, 7, 13	●			●					
Public Agenda, 2002, 1.	●								
Schneider, 2002, p. 15			●						
Scholastic Administrator, June 2004, p. 46				●					
Shorr, 2004, p. 26					●				
SREB, 2003, p. 2				●					
SREB, 2003, p. 4.		●					●		
SREB, 2003, p. 9					●				
Stevenson, 2002, p. 2	●								
Stevenson, 2002, p. 2			●						
Stevenson, 2002, p. 4					●				
Thonsburg, 1999, p. 4,3			●		●				
Webb, 1999, p. 2						●			
Wright, 2003, p. 26				●					
Wright, 2003, p. 26							●		
Wright, 2003, p. 28		●							

CATEGORY 1 - SCHOOL SIZE AND ORGANIZATION

1A. 1 A. School enrollment should not exceed 1000

1B. 1 B. School should be organized into career/learning academies

1C. No more than 25 students per class

1D. Shared school facilities with post secondary

1E. Longer school day/flexible scheduling

1F. Industry standard curriculum

1G. Comprehensive high school curriculum

1H. Rooms designed larger - 1200+ sq ft

1I. Smart card technology to manage student accounts

Category 2

CITATIONS	INSTRUCTIONAL SPACES									
	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J
Barton, 1995, p. 77							●			
Boettcher & Morrow, 1995, p. 139			●		●					
Chilton & Dalen, 1995, p. 131					●					
Crumpacker, 1995, p. 42	●									
Fielding, 1999, p. 2									●	
Fiske, 1995, p. 9, 6	●									●
Gonzales, 1995, p. 44							●			
Hardt, 1998, 61								●	●	
Holcomb, 1995, p. 17	●									
Holcomb, 1995, p. 18			●							
Kennedy, 2001, p 2		●								
Kennedy, 2001, p. 2; 2002, p. 1	●									
Kennedy, 2001, p. 4, 3				●		●				
Kennedy, 2001, p. 5							●			
Lyons, 2001, p. 6	●									
Lyons, p. 6, 1		●					●			
Marinello & Polney, 2001, p. 1					●				●	
Moore & Lackney, 1995, p. 17,	●	●								●
NASBE, 1996, p. 7, 15, 9, 20	●						●			●
NSBA, 1996, p. 17						●				
Ratell, 2004, p. 13	●									
Ratell, 2004, p. 13		●								
Ratell, 2004, p. 13								●		
Rush, 2001, p. 2					●					
Schneider, 2002, p. 6			●							
Stevenson, 2002, p. 3	●									
Whitehead, Jensen & Boschee, 2003, p. 178		●								
Yung, 1995, p. 69			●							

CATEGORY 2 - INSTRUCTIONAL SPACES

2A. Flexible instructional space

2B. Integrated/cross curriculum learning spaces

2C. Dimmer light switches

2D. Laptop plug-ins stations

2E. Interactive, wireless white boards & teacher podiums

2F. Minimum one electrical outlet per student

2G. ADA accessible space and equipment

2H. Dedicated & equipped TV production space and editing equipment

2I. Lecture/meeting hall with professional, conference grade technology

2J. Professional (not social) teacher work rooms with network connections, telecommunications, etc.

Category 3

CITATIONS	INSTRUCTIONAL TOOLS									
	3A	3B	3C	3D	3E	3F	3G	3H	3I	3J
Boettcher & Morrow, 1995, p. 140	●									
Bransford, Lin, & Schwartz, 2000, p. 12						●				
Burrall, 2004, p. 1										
Burrall, 2004, p. 1										●
Collins, 2004, interview					●					
Cook, 2002, p. 2,3			●				●			●
Corey, 2005, p. 1		●		●			●			
Cutshall, 2003, p. 21						●				
Edwards, 2004, p. 1						●				
Edwards, 2004, p. 1							●			
Emerging Technologies, 2004, p. 17, 6, 4, 7,10				●				●	●	
Hardt, 1998, p. 68										●
Leverett, 2001, p. 1				●		●				
Murray, 2004, p. 25						●				
NASBE, 2001, p. 4				●						
NASBE, 2003, p. 1, 7						●				●
Patrick, 2004, p. 14				●	●					
Poftak & Gold, 2004, p. 1			●							
Rush, 2001, p. 2	●									
Rush, 2001, p. 2				●						
Rush, 2001, p. 3							●			
Shorr, 2004, p. 12 & 2004, p. 32			●	●		●				
SREB, 2003, p. 12			●			●				
Thornburg, 1999, p. 1						●				
Thornburg, 1999, p. 8			●			●	●			
Valiant, 1995, p. 62						●				
Woolard, 2004, p. 1						●				

CATEGORY 3 - INSTRUCTIONAL TOOLS

3A. Video projectors in all classrooms
3B. Electronic or web based textbooks

3C. Handheld computing devices for students
3D. Online or web assisted learning options

3E. Laptop screen capture/control software
3F. More than average money & time for professional development/training

3G. Laptops or tables for all staff & students
3H. Datacasting capabilities

3I. Student Internet mail addresses hosted in-house
3J Portable storage devices (iPod)

Category 4

CITATIONS	TECHNOLOGY INFRASTRUCTURE															
	4A	4B	4C	4D	4E	4F	4G	4H	4I	4J	4K	4L	4M	4N	4O	4P
Boettcher & Morrow, 1995, p. 139				•	•							•				
Chilton & Dalen, 1995, p. 126					•											
Corey, 2005, p. 32					•					•	•					
Corey, 2005, p. 35															•	•
COSN, 2004, p. 12		•														
Dermody, 1995, p. 45			•													
Emerging Technologies, 2004, 16																•
Enderle, 2003, p. 1				•	•		•	•			•			•		
Hardt, 1998, p. 9, 59, 64				•	•				•	•						
Holcomb, 1995, p. 18, 70					•			•			•					
Kennedy, 2001, p. 4								•								
Kennedy, 2002, p. 2						•										
Lyons, p. 2												•				
Lyons, p. 9						•										
Moore & Lackney, 1995, p. 21								•								
NASBE, 1996, 17, 17, 17					•				•		•		•			
Poftak & Gold, 2004, p. 1				•												
Poftak & Gold, 2004, p. 1							•			•						
Ratell, 2004, p. 14											•					
Ratell, 2004, p. 14													•			
Safeguarding, 2004,															•	
Schenider, 2002, p. 2	•					•										
Shorr, 2004, p. 28								•								
Valiant, 1995, p. 64											•		•			
Yung, 1995, p. 67					•				•		•		•			

Article I. CATEGORY 4 – TECHNOLOGY INFRASTRUCTURE

4A. Roving wireless security protocol	4G. Web accessible security cameras	4M. Centralized head-end room
4B. School Interoperability Framework	4H. "Better than average" AC systems	4N. Broadband access 24/7
4C. Multiple firewalls and most up-to-date secure network affordable	4I. "Better than average" campus electrical system	4O. High quality cyber security system
4D. IP voice and video system	4J. Network remote access & self monitoring file servers	4P. Programmable phone systems
4E. Easily accessible, exposed wiring/cabling	4K. Fiber optic cabling	
4F. Computer controlled/monitored HVAC	4L. Wireless environment	

Category 5

CITATIONS	COMMON AREAS, FURNITURE AND DECOR							
	5A	5B	5C	5D	5E	5F	5G	5H
Crumpacker, 1995, p. 41						●		
Custhall, 2003, p. 18							●	
Fickes, 2003, p. 18							●	
Hardt, 1998, p. 53, 65	●				●			●
Holcomb, 1995, p. 18		●						
Kennedy, 2002, p. 2, 3			●			●		
Loomis, 1995, p. 72					●			
Lyons, 2001, p. 5					●			
Moore & Lackney, 1995, p. 19, 21		●			●	●		●
Moscoe, 1995, p.63						●		
NASBE, 1996, p. 7						●		
Ratell, 2004, p. 15							●	
Ratell, 2004, p. 16						●		
Simmons, 1995, p. 79, 80			●	●			●	
Tanner, 2000, p. 1							●	

CATEGORY 5 - COMMON AREAS, FURNITURE, AND DÉCOR

5A. Fully wired media center

5B. Digital monitors to display student work in common areas & Media Center

5C. Ergonomically correct furniture

5D. Flat top computer tables

5E. Daylighting to balance lighting levels

5F. Group work tables/stations & meeting areas

5G. "High tech" looking architecture, entrance & furniture

5H. Centralized graphics/production production lab for various instructional programs