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ABSTRACT

This study, targeting grades four through eight, evaluates New York City's options for incorporating educational technology into classrooms within existing school facilities. The study reports on: (1) what physical configurations of educational technology can best accommodate different and evolving methods of integrating computers into the curriculum; (2) what configurations existing classrooms can support with regard to space, equipment location, and electrical power; and (3) what configurations will be most cost effective and workable with existing conditions. (GR)

Educational Technology Options

for New York City Public School Classrooms

Prepared for:
The New York City School Construction Authority

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Introduction & Methodology

This is a study, prepared for the New York City School Construction Authority, whose principal aim is to provide options for the incorporation of education technology into classrooms within existing New York City public school buildings. This study is particularly targeted at grades 4 through 8.

This study was performed over a four week period in March and April of 1997. The primary questions that the study sought to address are:

- What physical configurations of educational technology can best accommodate different and evolving methods of integrating computers into the curriculum?
- What configurations can existing classrooms support with regard to space, equipment location and electrical power?
- What configurations will be most cost effective, and work with existing conditions, while meeting the criteria of the previous two questions?

The methods used in this study include a review of precedents throughout the nation and overseas; correspondence with representatives of selected schools in the United States and Australia; visits to selected sites in New York City, including Public School 66 in Richmond Hill, Queens; and a review of recent trends in the computer hardware and software industries.

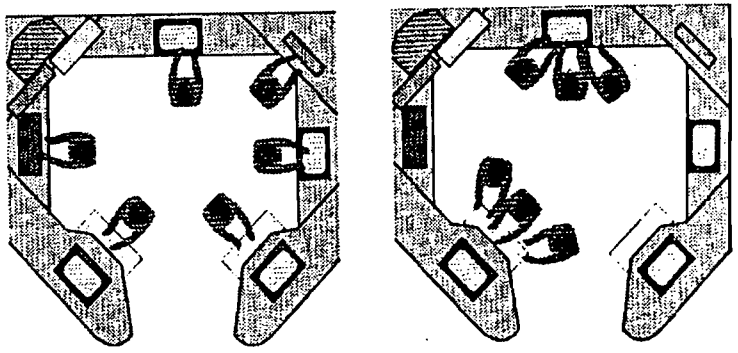
Underlying the study are several basic assumptions, including an understanding that four computers and one printer will be provided to each fourth through eighth grade classroom as part of a forthcoming NYC Board of Education program. In an era where no single educational philosophy currently exists with regard to how technology should be applied in classrooms, certain assumptions had to be made about how the technology might be applied. For example, based upon a variety of precedents, scenarios were con-

sidered where the number of students working at computers ranged from one student at a time to as many as six students working as a group.

The options presented in this report have been developed to address up to four students per computer at one time. However, since four is a large number of students to use a computer at one time, the study does not assume that this will typically be how the computers are used. Groups larger than four students per computer generally require more square footage and specialized equipment than the forthcoming program will be able to provide.

Scenarios were also considered where one of the four computers would be dedicated as a teacher's station and also be available for student use. Distinguishing this computer from the others, in certain scenarios, permits it to be outfitted, initially or in the future, with more robust multi-media, communications and presentation capabilities and act as a nexus for the students' computers.

These scenarios were then considered in relation to typical classroom layouts and equipment as well as the constraints inherent in existing electrical systems.



Individual Work *Small Group Work*

Above: A plan diagram of a six student work station. (from Redefining the Place to Learn, NJIT, 1994)

Executive Summary

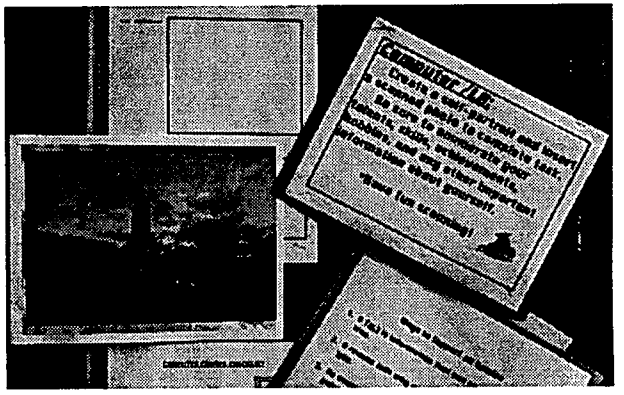
Throughout the nation and, in fact, around the world, advances in educational technology are having a dramatic impact on primary and secondary education and they are also having a dramatic influence on the physical environment that we provide as a setting for our children's education.

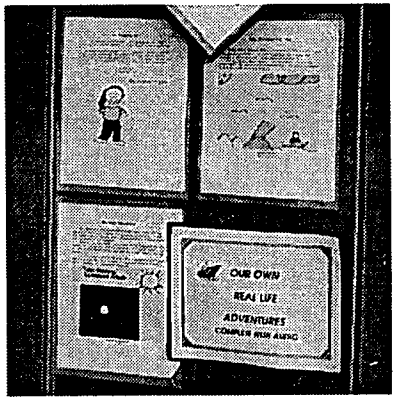
Educational technology is integrated into schools across the nation in widely varying ways. The possible permutations on how computers are applied to primary and secondary education are virtually as numerous as there are numbers of teachers. Some schools use technology for the remediation of basic skills, while others use technology to "teach across the curriculum" and create "learner-centered" curricula. However, one pervasive trend is that technology is no longer principally being placed in separate computer labs. It is being integrated directly into the classroom and used as a tool for learning rather than being considered primarily as a subject unto itself.

This integration of technology into schools, and classrooms in particular, is accelerating and the New York City public schools are now well positioned to take advantage of the experiences of other schools throughout the world that have led the way. With this in mind, the Board of Education and the School Construction Authority have made the commitment to install four computers and one printer in the system's fourth through eighth grade classrooms.

Student to Computer Ratios and Lesson Planning

In comparison to many of these precedent schools, this allocation of resources — resulting in a student to computer ratio of approximately seven-to-one, assuming a typical class of twenty-seven students — is not unusual for primary or secondary schools in the United States. A seven-to-one ratio of students to computers can permit the development of lesson plans that engage between one-seventh to one-third of a typical class at the computers at one time.





Above: Two displays of students' computer generated work. (PS 66, Richmond Hill, Queens)

(The 7:1 ratio is derived by one student working at each computer, while the 3:1 ratio is derived by two students working together at each of three computers and three students working together at one computer.) Groups of students of these numbers are also consistent with many teachers' approaches to lesson planning, particularly when one-third of the class can be engaged in an activity at a single time. The options presented in this document have been developed to address this range of students using the computers. (See Note 1)

Existing Classrooms and Infrastructure

New York City Board of Education owns approximately 1,100 schools that were built over a period of approximately one hundred years. Most of the classrooms in these buildings were not intended to house computer technology. In fact, these classrooms are often relatively small for the number of students, and the amount of equipment, that are already housed within them. Students' desks typically occupy most of the free floor space.

In some instances, these spatial constraints will rule out the use of certain space intensive configurations of computer stations. For example, "island" configurations generally require greater circulation space than other configurations.

Much of the perimeter of these classrooms is typically occupied by built-in casework and tack and chalk boards, and windows and heating equipment often occupy a large percentage of the exterior wall. The placement of fixed computer stations along the perimeter wall will accordingly, require that a balance be struck between the use of these existing features and the new computer stations. The windows also introduce a potential for glare on the computer screens that must be considered with fixed computer stations.

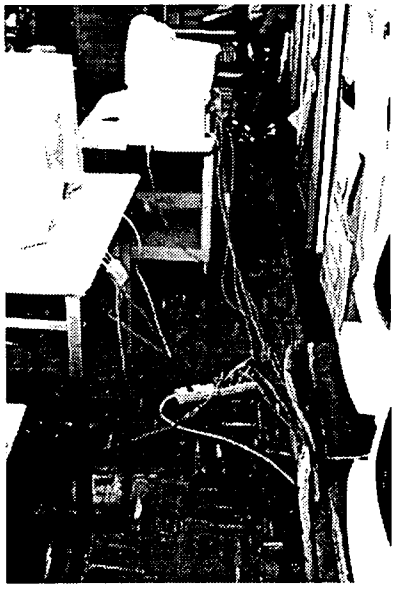
Another deciding factor in installing educational technology into existing buildings is the available electrical power and distribution infrastructure. Many of New York City's school buildings have limited unused electrical capacity in their distribution systems and the capacity that is available may be provided to each classroom through a single, inconveniently located wall outlet.

At P.S. 66, for example, where there are fewer computers per classroom on average than the forthcoming BOE/SCA program is proposing, it was noted that electrical circuits are often "blown." Locating fixed computer stations in the school requires a decision between locating near an available a/c outlet, developing a code approved outlet assembly to enable placing computers where they integrate best with the available space and the lesson plan, or reworking the electrical distribution system. Similarly, if power is not available, both the capacity and the distribution system will have to be reworked.

With the limited resources available to this BOE/SCA program, the challenge will be to allocate the greatest amount of money available directly to the investment in computers, printers and software versus upgrading inadequate electrical infrastructure.

These circumstances and assumptions provided the context for preparing the options presented in this study. The options have been developed using both "desktop" and "laptop" computers. These options are designed to enable educational technology to be deployed in varying configurations depending upon the opportunities and constraints presented by each classroom and school building and to accommodate a variety of teaching strategies.

Hybrid solutions, using a mix of desktop and laptop computers, may be developed from the elements of several options. Finally, a decision-making framework is presented after the options to assist in the selection of the appropriate configuration.



Above: Inadequate space and a/c distribution can result in hazardous cabling situations.

Guidelines

The following general guidelines should be considered when installing educational technology into the classrooms. Please note that the applicability of certain guidelines may change if laptop computers are used.

- At least two people should be able to comfortably work together at a single computer. These could be two students or a student and the teacher or a teacher's aid. This room may be provided by strategically placing desks so that no more than two computers sit directly adjacent to one another or by distributing the computers on surfaces of sufficient width for two to work comfortably at a computer.

- Appropriate space for circulation should be left behind the computer station. Normally a space 3'6" deep, measured perpendicularly from the edge of the table, should be provided for circulation space behind the computer stations.

- Computers should be situated to minimize glare from windows and overhead lighting. In general, computer screens and/or their viewers should not directly face windows.

- Provide accessible computer stations that are designed to accommodate mobility impaired students.

- Consider where network cabling may be run through the building in the future and locate computer stations to conveniently be able to "tie into" this network. For example, if the corridor will be used to distribute the network cabling, locate the computer stations, if possible, so that they can accept feeder lines directly from the corridor wall.

- Purchase furniture that has integral cable management features. Carts should have power strips built-in.

Consider locating telephone jacks adjacent to the computer stations to provide access to the Internet and other online services. (Cart-based or laptop computers may be moved to jacks.)

Provide additional storage for floppy disks, CD-ROM's, printer paper and toner cartridges, and other assorted computer related supplies.

The Components

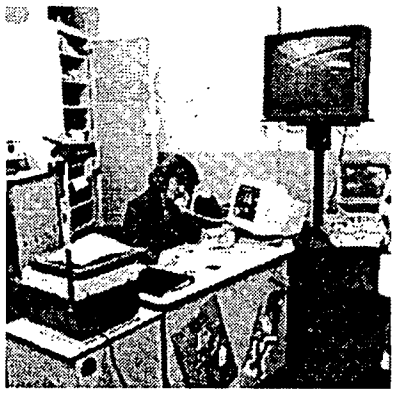
The most fundamental components to be installed in the classrooms are computers and printers. The dimensions and attributes of these components vary by manufacturer. Extensions of this basic system may include, at a later date and under a different capital program: scanners, digital cameras, audio and video devices and a variety of output devices including large format screens and video systems.

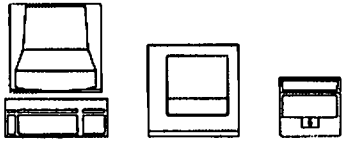
Accordingly, this study has been developed around the initial allocation of four computers and one printer per classroom. These four computers can be distributed in a variety of configurations that will be presented in the next section, but for the moment, two variations should be considered with regard to how these four computers are allocated.

The first variation treats, and outfits, all four of the computers the same. A second variation outfits one computer with more robust multi-media, communications and presentation capabilities than the other three. This concentrates expenditures on one computer which may provide the students with access to features that could not be afforded for all four computers (e.g.: a larger screen, a faster micro-processor, more advanced multi-media production and presentation tools, etc.)

In this second variation, students could begin multi-media projects on one of the other three computers and then transfer their files to the "teacher's station" for final production and presentation. In options using laptop computers, the teacher's station can also be used as a fixed printing or demonstration station. In all of the options presented, the teaching station may be remotely located in relation to the students' computers, such as at the teacher's desk.

With regard to the spatial requirements of these components, it is assumed that all of these computers will have a mouse, trackball





Top: *A teacher's station with a large presentation screen (from The Seattle Schools School Design Notebook, NJIT, 1992)*

Above: *A plan diagram of a desktop computer, a printer and a laptop computer.*

or a similar pointing device, and that some computers may have external audio speakers.

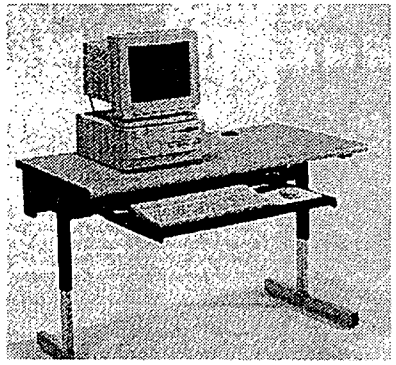
A desktop computer, a mouse and external speakers, in addition to needed work space adjacent to a desktop computer (for books, pencils and paper, CD-ROM and floppy disk cases, etc.), can comfortably be accommodated on a 30" deep by 42" wide, or larger, work surface. This dimension would also permit two students to work comfortably side by side at each computer station.

In contrast to desktop computers, the compact "footprint" and integrated pointing devices of laptop computers do not require work surfaces to be as large and, with the exception of a charging and printing station, they do not require dedicated furniture.

The work surface modules used per computer for this study range from 30" by 42" down to 30" by 30." The smaller dimension, while very adequate for one student, inhibits the ability of two students to work together. As the width decreases, the potential for comfort and flexibility may be compromised, particularly for older students.

In some instances, the depth of the work surface can be reduced by specifying furniture that features pull-out keyboard/mouse trays mounted beneath the table top. However, a 30" depth for the work surface may provide the flexibility to place a printer, or at a later date, a scanner or other peripheral device, at the back of the surface that lesser dimensions may not provide.

The specification of furniture components must also address accessibility issues. Because of its unique features, the teacher's station may also adapt well to being an accessible station.



Above: An example of a computer station with a pull-out keyboard and mouse tray.

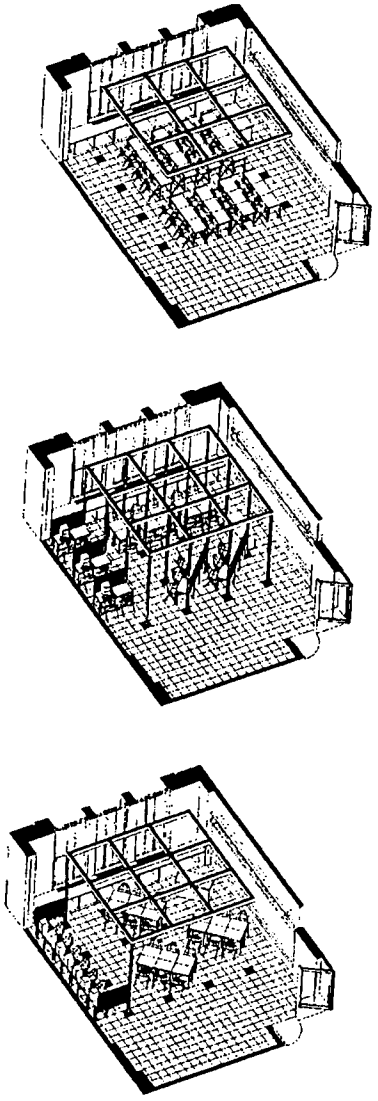
Cable management systems

Desktop computers typically require an array of power and data cabling. This cabling can present a tripping hazard, occupy precious work surfaces, detract visually from the classroom and in some instances violate the Building Code. New furnishings bought for this program should take advantage of the many cable management systems that have been integrated into systems furniture, such as cable troughs concealed in modesty panels and vertical cable channels concealed within table legs.

Consideration should also be given to the physical requirements of providing building-wide data access in the future. Currently this requires additional space in cable troughs and channels. However, these requirements are changing as "wireless" technologies evolve.

With provisions for new infrastructure, in most of the options presented, a/c access can be gained directly from wall mounted outlets. The exception is the "island configuration." Assuming that the only a/c outlets provided are wall mounted outlets, power for islands will have to be supplied through the floor, or from the ceiling through "power poles." The former may require drilling through the floor to provide access and the latter may require running conduit across the ceiling of the classrooms or running cable above a dropped ceiling.

If new power and distribution systems are provided to correct for inadequate existing power, the new systems should be designed for, perhaps, two or three times the utilization of computers than is currently being proposed. This will, as the use of educational technology continues to increase, reduce the likelihood of having to perform another electrical upgrade in the foreseeable future.



Left: A series of diagrams showing how a classroom was designed to use power poles, connected to a ceiling grid, to accommodate varying configurations of educational technology. (Ehrenkrantz & Eckstut Architects' Prototype School System)

The Options

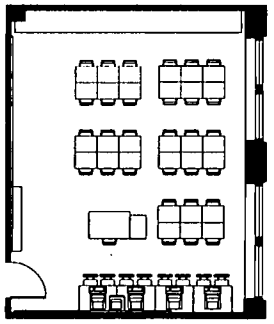
The options for installing educational technology in existing classrooms can be divided into two broad categories based upon the degree of mobility inherent in the configuration. A third category can be developed through hybrids created by combining elements contained in the two other categories.

The two basic categories are: Stationary Systems and Portable Systems. Stationary systems use desktop computers and printers that are placed and powered in fixed locations. Portable systems are more or less available to be relocated throughout the classroom and in some circumstances, beyond the classroom.

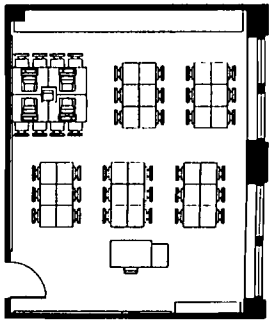
However, for one of the portable system options, it should be noted that laptop computers require recharging and storage stations which may be served by the electrical system when the classroom's lighting is turned off. A disconnect switch may be needed to ensure that recharging does not occur during periods when the demand for electricity is great. Another option is to provide recharging during the day from an available outlet if adequate power is available. (See Note 4 for more detail.)

The two primary categories can be further subdivided into the following types:

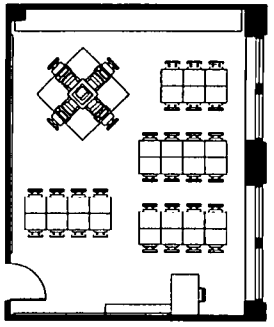
- Stationary Systems
  - 1. Perimeter configurations
  - 2. Peninsula configurations
  - 3. Island configurations
- Portable Systems
  - 4. Cart-based configurations
  - 5. Laptop configurations
- Hybrid Systems include:
  - 6. Desktop and laptop configurations



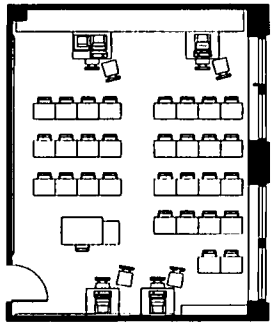
Option 1 - Perimeter



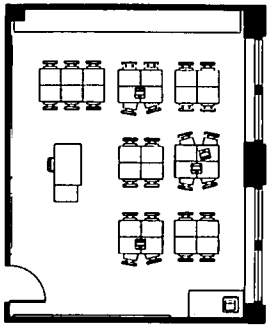
Option 2 - Peninsula



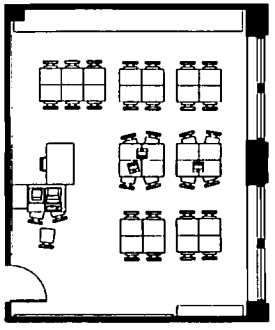
Option 3 - Island



Option 4 - Carts



Option 5 - Laptops



Option 6 - A Desktop & Laptops

On the previous page, a diagrammatic floor plan showing one possible application of each configuration in a classroom was presented. On the following pages, a larger diagram of each of these configurations is presented along with its advantages and disadvantages.

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1. Stationary Systems — Perimeter Configuration

Basic Components

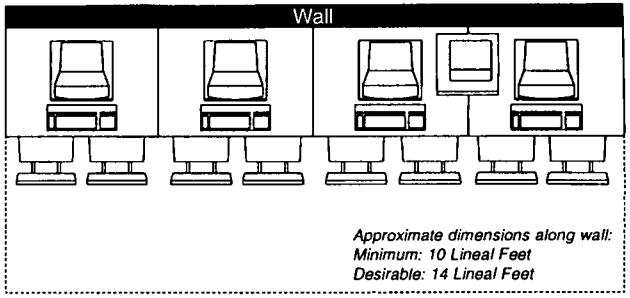
- Four Desktop Computers
- Four Computer Stations with Chairs
- One Printer

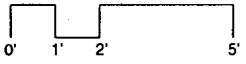
Advantages

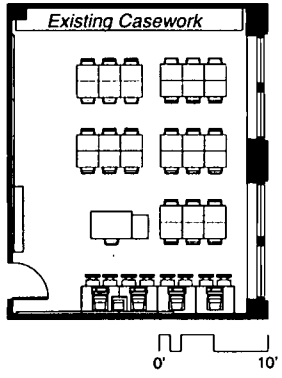
- Potential for convenient a/c and data access from the wall.
- May have potential to be integrated into perimeter casework.
- Stations may be located adjacent to one another or distributed.
- Adjacency may facilitate local networking of computers, permitting the sharing of data and resources (i.e.: printers) among computers.

Disadvantages

- May occupy limited wall space that is being used, or that could be used, for other activities or equipment.
- Glare may be an issue if the computers face exterior windows.
- If the perimeter space is limited, the size and adjacency of furnishings may in turn limit the number of students able to work at each station.







Top: *Photo of Perimeter configuration at PS 66.*

Above: *Plan diagram of the Perimeter Configuration. The desks measure 30" by 42". Dashed line represents circulation.*

Left: *Plan diagram of Perimeter configuration in typical classroom*

2. Stationary Systems — Peninsular Configurations

Basic Components

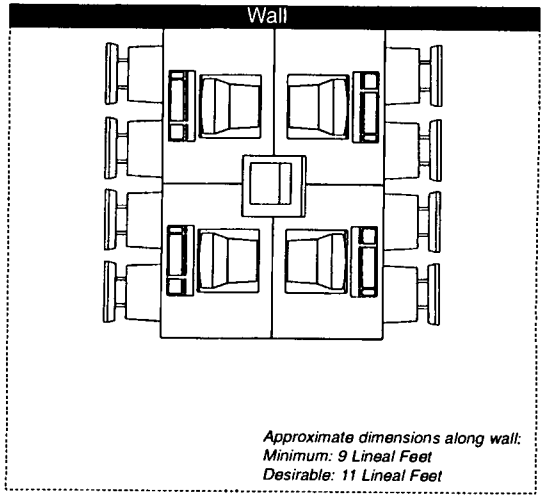
- Four Desktop Computers
- Four Computer Stations with Chairs
- One Printer

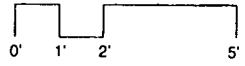
Advantages

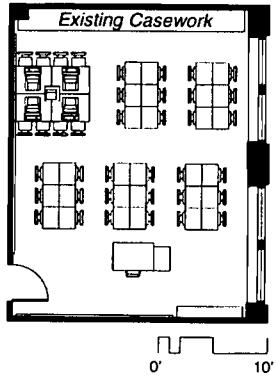
- Potential for convenient a/c and data access from the wall.
- Stations may be located adjacent to one another or distributed.
- May have potential to be integrated into perimeter casework.
- Adjacency may facilitate local networking of computers, permitting the sharing of data and resources (i.e.: printers) among computers.
- The corners of the work stations, if unobstructed, may provide increased opportunities for students to gather around a computer.

Disadvantages

- Glare may be an issue if computer screens face exterior windows
- May require more circulation/total square feet than Perimeter Configurations.
- May occupy limited wall space that could be used for other activities or equipment (albeit less space than is required for the perimeter configuration.)
- Size and adjacency of furnishings may limit the number of students able to work at each station.







Above: *Plan diagram of the Peninsular Configuration. The desks measure 30" by 42". The dashed line represents circulation.*

Left: *Plan diagram of Peninsular Configuration in typical classroom.*

Note: *The photo on the cover is of a Peninsular Configuration at PS 66.*

3. Stationary Systems — Island Configurations

Basic Components

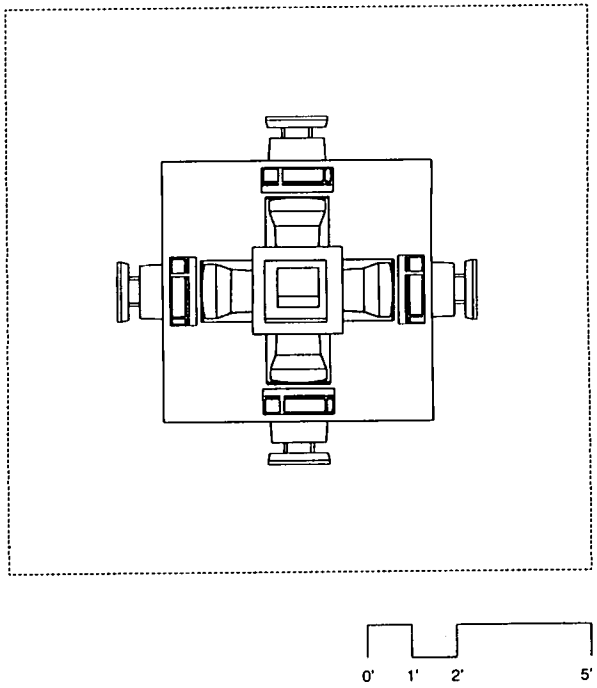
- Four Desktop Computers
- Four Computer Stations with Chairs
- One Printer

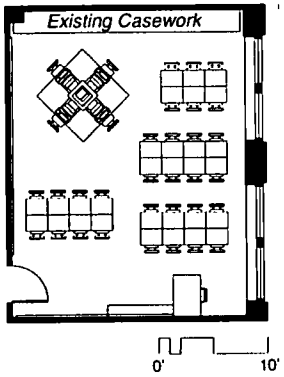
Advantages

- Adjacency may facilitate local networking of computers, permitting the sharing of data and resources (i.e.: printers) among computers.
- Has greater potential to accommodate multiple students at each station than some perimeter and peninsular configurations.
- Is a good configuration for group learning activities. (While outside of the scope of this study, it should be noted that this configuration works particularly well in library and laboratory settings.)

Disadvantages

- A/C and data access must be provided through the floor or from the ceiling.
- May require the greatest amount of square footage of all of the options.





Above: *Plan diagram of the Island Configuration. The table can vary in size and shape. In this example, each side of the table is 6-feet long and the printer is elevated above the computers on a shelf. The dashed line represents circulation.*

Left: *Plan diagram of an Island Configuration in typical classroom.*

4. Portable Systems — Cart-Based Configurations

Basic Components

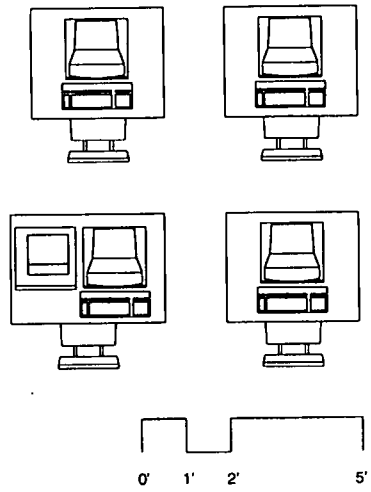
- Four Desktop Computers
- Four Computer Carts
- One Printer

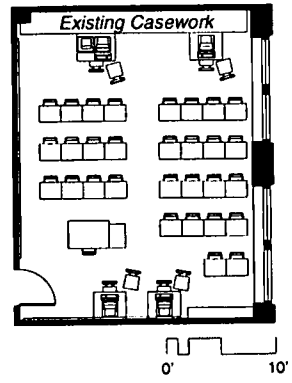
Advantages

- When not in use, stored carts may require less space than desktop computers located on stationary desks. For example, they may be able to be stored in traditional cart storage areas under counters.
- The number of students that can sit around a computer on cart is not necessarily limited by adjacent fixed objects.
- Portability could facilitate sharing of the computer resources between classrooms if a/c outlets are available.
- Portability can enable computers to access distributed a/c outlets throughout the room, if available.

Disadvantages

- A/C and data access may be a problem.
- Mobility may be limited by the available circulation within the classroom.
- Actual mobility may be limited by the time required to set-up and store the carts.
- Trailing wires will present problems if the carts can not be located directly adjacent to a/c outlets.
- A/C must be distributed throughout the classroom.





Above: *Plan diagram of four cart-based desktop computers. The cart on the lower left measures 30" by 42" and also has a printer. The other carts measure 30" by 36".*

Left: *Plan diagram of a Cart-based Configuration in typical classroom. Note that the carts can be located adjacent to any open, unobstructed a/c outlet and compactly stored after use.*

5. Portable Systems — Laptop Computer Configurations

Basic Components

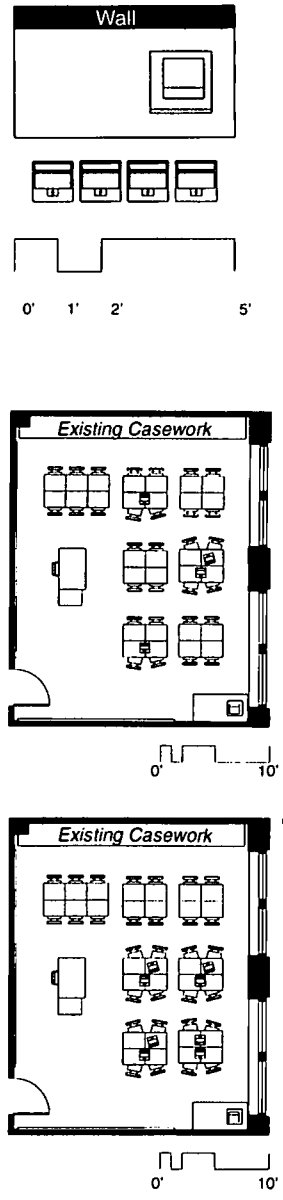
- Four Laptop Computers
- One Charging Station (Fixed or Mobile) for Four Laptop Computers
- One Printer

Advantages

- Requires the least amount of dedicated furnishings and space of all of the options.
- May place the smallest draw upon existing power resources. Demands on the electrical infrastructure for battery charging may be shifted to off-hour periods
- The computers can be freely distributed throughout the classroom enabling them to be fully integrated into the curriculum.
- Adjacency to other computers or furnishings is not inherently a constraint on the number of students that can work together at the computers.
- Laptop computers, in general, have evolved to the point of being comparable to desktop computers in processing power and available peripherals. Screen resolution and size are both increasing and "active matrix" or "Thin Film Technology" screens provide high quality displays.

Disadvantages

- Battery life in Portable Computers is currently limited requiring the use of multiple batteries over extended periods of time.
- A printing station will need to be provided in the classroom,



Top: *Plan diagram of the components of the Laptop Configuration. The printer is shown sitting on a 30" by 60" re-charging station. This station could be built into existing casework.*

Above: *Plan diagram of Laptop Configuration in typical classroom.*

Left: *Plan diagram of Laptop Configuration in typical classroom if two classes were to share laptops. (See Note 3).*

at the recharging station, or in a common resource center.

- Laptop computers are generally more fragile than desktop computers. (see Note 2)
- Laptop computers can be more expensive than desktop computers depending upon the features selected.
- The portability of laptops increases the need for security precautions. Heavier and larger laptops may mitigate this problem somewhat.

6. Hybrid Systems — One Desktop and Three Laptop Computers

Basic Components

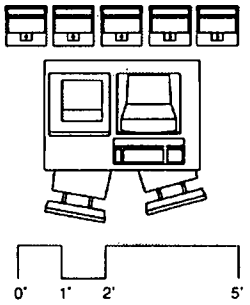
- One Desktop Computer
- One Computer Station with Chair
- Three Laptop Computers
- One Charging Station (Fixed or Mobile) for Three Laptop Computers
- One Printer

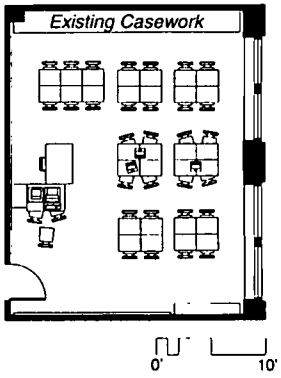
Advantages

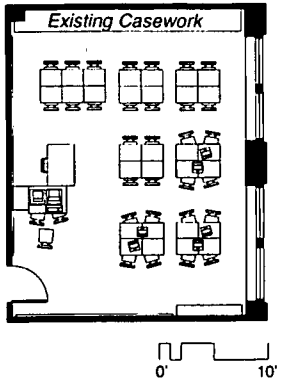
- Three computers can be freely distributed throughout the classroom enabling them to be fully integrated into the curriculum.
- Adjacency to other computers or furnishings is not inherently a constraint on the number of students that can work together at the computers.
- The desktop computer can be cart-based to also provide mobility.
- The desktop computer can act as a printing and demonstration station for work begun on the laptops.
- The desktop computer can also be configured to provide greater storage, communications and presentation capabilities than the laptops, concentrating expenditures on one computer to provide features that would not otherwise be available.

Disadvantages

- Same as Option 5.







Top: *Plan diagram of the Hybrid Configuration. Three laptops are shown above a cart-based desktop computer and printer. Recharging station for the laptops is assumed to be in casework.*

Above: *Plan diagram of the Hybrid Configuration in typical classroom.*

Left: *Plan diagram of the Hybrid Configuration in typical classroom if two classes were to share laptops (see Note 3).*

Decision Making Framework

In this section we have developed a decision making framework to help select the appropriate option for particular circumstances.

The basic decision making framework can be summarized in four questions:

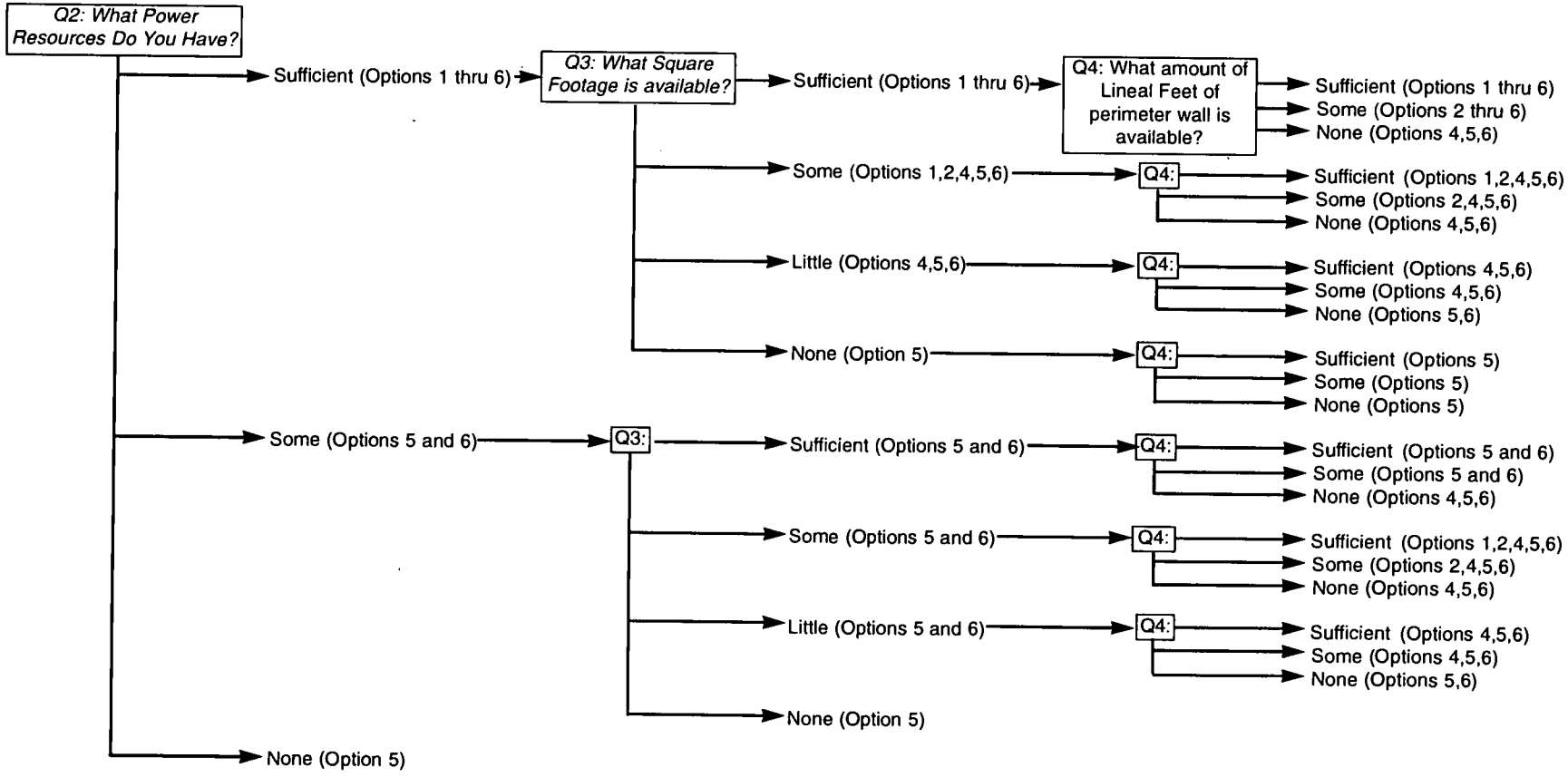
1. Are there any overriding curricular demands that require one configuration versus another?
2. What are the constraints on the power supply to the classroom?
3. How much available square footage is available?
4. How much lineal feet of perimeter wall space is available?

By answering these questions in sequence, the most appropriate option can be easily selected. The decision tree presented on the following page, is a graphic representation of this process. If the answer to the first question posed above is "No," then responses to the next three questions will move the inquiry through the branches of the tree until only the most viable options are left for consideration. If the answer to the first question is "Yes," then the use of the tree is unnecessary and power and space should be provided (if it is economically feasible) to accommodate the selected option.

For reference, the Options are numbered:

1. Perimeter
2. Peninsular
3. Island
4. Cart-based
5. Laptop
6. Hybrid (desktop and laptop)

Decision Tree



Recommended Option

Before proceeding, it should be noted that this recommendation is based on limited data. The short time frame in which the study was performed did not permit visiting a significant number of schools or talking with many teachers that are currently utilizing educational technology in New York City. However, returning to the three questions presented in the Introduction regarding the constraints of existing infrastructure and space, flexibility to accommodate trends in using educational technology in classrooms, and the need to achieve the greatest return on the investment, has influenced us to offer a recommendation.

The decision-making framework presented in the previous section is structured to enable the selection of the most appropriate options considering site specific conditions and to respond to particular curricular requirements. Unless there is a specific circumstance that requires the use of another option, we recommend the following option be implemented.

Recommended Option

Our recommended option is Number 6, a hybrid using one desktop computer, three laptop computers and one printer connected to the desktop computer. This option is recommended because it:

- Minimizes the impact on, and any associated modifications to, existing electrical infrastructure. (See below for further detail.)
- Requires almost no dedicated furniture, reducing expenditures on furniture and freeing valuable floor and perimeter space for other activities.
- Creates the greatest potential for students to work both individually or collaboratively in groups comprised of up to four students by removing limitations resulting from adjacency conflicts between computers.

Top: *Students using laptop computers at Methodist Ladies' College. (from Redefining the Place to Learn, NJIT, 1994*

- Creates opportunities for sharing computers between classes. For example, two classes could share six laptop computers between them. With the addition of a fixed or cart-based desktop computer in each class, seven computers can be in use in a classroom at one time.
- Provides a fixed printing and presentation station at the one desktop computer (that could be cart-based) which can also be outfitted, initially or in the future, with more robust multi-media presentation and communications capabilities than available in the laptops.
- Permits students to use the laptops in a variety of settings around the classroom. For example, a student could use a laptop at his or her desk, at a library/resource center, at the teachers desk, at a science center, or at all of the above.
- Would be a significantly faster option to implement than most of the other options that would require more substantial modifications to a building's electrical power and/or distribution system. In short, more of the City's investment would be allocated directly to purchasing computers and software.
- Would easily accommodate additional laptop computers in the future without requiring virtually any additional space.

According to one source at Consolidated Edison's research division, using laptop computers is the most viable option for installing educational technology in most existing schools without extensive modifications to the electrical infrastructure.

Laptop computers can be operated either from a battery or they can be plugged in with an a/c adapter. Current battery technology provides between 1 and 2 hours of use per battery and many models offer the ability to swap batteries quickly. (At the Methodist Ladies' College in Kew, Victoria, Australia, where every student (spanning ages 6 to 18) has a laptop computer, strategies to mini-

Top: *Students using laptop computers in "the field". (from Portable Computers Pilot Evaluation Report, NCET, Coventry, England, 1994*

mize energy usage have generally extended battery life to two hours.) Spare batteries could also be provided to extend the use of the computers. As well, some models have the option of using two batteries at a time.

Even when plugged in via an a/c adapter, laptops draw less power than desktop computers. Measured in Watts (W) for example, a laptop generally requires only 35W to 70W, while a comparable desktop computer requires 145W to 200W for the computer itself and another 100W for the monitor.

To recharge and store laptop computers, several schools studied as precedents (including the Covington School in Birmingham, Michigan and the Methodist Ladies' College) have developed secure shelves or carts where the computers can be locked up while recharging. The Covington School design is cart-based and it is accordingly, available to be moved to whatever classroom needs the computers (similar carts are commercially available). To reduce demand for a/c power during the day recharging the laptops' batteries can be limited to off-peak hours, for instance, over night. As well, in some instances, enough power may be available to recharge batteries during the course of the day. (See Note 4)

The recharging station does not have to be much larger than the combined size of the laptop computers and a six battery recharger. It may be possible to build the recharging station right into existing casework. Another idea to consider is that the Covington School's recharging/storage stations have been designed to accommodate to additional laptops that may be purchased in the future.

Notes

1. The Covington School, in Birmingham, Michigan, featuring a science and technology-oriented program for grades 3 through 8, has a current student to computer ratio of 6 to 1. The student to computer ratio has important implications for lesson planning. If one-third of the class cannot be accommodated on the computers (in pairs) at one time, consideration should be given to designing so that additional computers can be added later. This situation may arise in classes that have over 27 students.

2. The computer hardware industry is beginning to address the "fragility" of laptop computers. Apple Computer, on its corporate Website, touts the forthcoming eMate 300 "mobile computer for education" as "rugged." According to one contact, the Thorton Middle School in Thorton, Colorado, based upon their experience with educational technology, and laptop computers in particular, is planning to (subject to available funding) provide six eMate computers in every classroom for a total of between 90 to 120 computers.

Following a study of 118 schools in England, that are using portable computers, the United Kingdom's National Foundation for Educational Research recommended the following when purchasing laptop computers:

- Carefully review the service contracts
- Check the quality of the screens
- Check that the hinges between the screen and the body are "robust."
- Check that the connectors used for the a/c adapters are solidly built. (Also noted at The Covington School.)

Robustness is also related to the weight of laptop computers and how much a child can reasonably carry. This was mentioned by Methodist Ladies' College in Kew, Victoria, Australia, where nearly

2000 laptop computers are in use by the students and at the Covington School, in Birmingham, MI, which provides over 60 laptop computers for student use. The contact at the Covington School suggested that while they have not had any laptops dropped, the computers should feature handles to make it easier for the children to carry.

3. One example of the portability of laptops enabling a class to increase the number of computers used by the students at one time is the Summit Ridge Middle School in Lakewood, CO. At this school two teams, of approximately 150 to 170 student each, share 30 laptops. These 30 laptops are available to each teacher for use during class, resulting in a one-to-one student to computer ratio. Teachers at Summit Ridge can also bring "a/v carts" into the classroom which have desktop computers with greater multi-media capability than the laptops. Both the laptops and the a/v carts can connect to a large video monitor provided to each classroom.

4. The ability to recharge batteries during the day may be desirable. The ability to do so is dependent upon several issues including the power consumption of the laptops specified, the type of battery used, power consumption of the battery recharger, the electrical capacity of the particular school, the existing distribution system and the number of open outlets.

As an example of the power required, one manufacturer's (single) battery recharger requires 18 volts at 2 amps. If the cumulative power requirements of a number of batteries charging at one time is too great, several chargers could be sequenced to recharge one or two batteries at a time.

Glossary

Charging Station	A place for recharging, and possibly for providing secure storage, for laptop computers and their batteries. The charging station could take on a variety of configurations including a mobile cart or a fixed cabinet. It could be built-into existing casework, to save space.
Desktop Computer	A computer that, by design, is relatively fixed in place. Typically, these computers have monitors, pointing devices and keyboards that are separate from a "case" containing the CPU and assorted peripherals.
Educational Technology	Electronic devices that are used as part of a curriculum, including computers, printers, scanners.
Laptop Computer	A computer that is designed to be largely battery operated. The elements comprising these computers (including screens, pointing devices and keyboards) are often integral to the housing design of these machines. In this document this phrase is used to also represent "notebook" and "sub-notebook" computers.

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