

Montessori Classroom Culture and Effective Use of  
Computers in the School

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## Abstract

In her book, Computers and Classroom Culture, Janet Schofield (1995) asserts that “it has become increasingly apparent that preexisting attitudes and social structures shape the extent to which technology is used as well as the way it is used”. In this study, a number of affordances and obstacles to effective use of computers in the Montessori classroom are proposed. Evidence for the existence of these affordances and obstacles are taken from interviews, observations, other studies, writings by and about Montessori, and personal experience as a Montessori teacher and as a computer programmer. An attempt is made to look at computers in the classroom from an incrementalist Montessori teacher’s perspective, and a suggestion is made to do the same from the incrementalist viewpoint of researchers and software developers in order to frame discussions on the future of computers in the Montessori classroom.

## **Introduction**

Before there was any such thing as a Macintosh or a PC, I spent three years as a Montessori teacher-in-training for children aged 2-12. At the end of that time, I got married, finished college, and began work as a computer programmer. In twelve years as a programmer and systems analyst in three large corporations and a university, I saw first hand and read about how computers were transforming the way people work, and I became increasingly curious about the impact that computers were having and could have on the way people learn. The more I wondered about it, the more I felt the need to go to graduate school and start conducting research.

The Montessori classroom struck me as a good place to start. For one thing, I am somewhat familiar with the Montessori method. For another, the logistics of the Montessori classroom seemed to lend itself to effective use of computers. The fact that Montessori kids are free to work independently, either alone or in small groups, means that some kids could be off working on a small number of computers at any time of day without disrupting the normal flow of classroom activities. Also, part of the work of the Montessori teacher is to evaluate didactic instruments to see how well they support learning, so I was interested in hearing what Montessori teachers had to say about computers in the classroom.

## ***Questions***

Computers are finding their way into Montessori classrooms. Every Montessori elementary school I contacted has computers in their classrooms for children 9 and older. Most make computers available to kids at age six, some at age three. How does computer

use in a Montessori classroom differ from computer use in a traditional classroom? What are the affordances and obstacles to effective use of computers in the Montessori classroom, and how do these compare with the affordances and obstacles in a traditional classroom? What can the Montessori method tell us about the effective use of computers? How should dialog between teachers, researchers and programmers (and administrators and students and parents) be conducted in order to promote effective use of computers in the classroom?

### ***Methodology***

Data was gathered through telephone interviews with Montessori students, teachers, administrators, and educational software developers and three site visits to two Montessori schools, as well as informal discussions with software developers and researchers. The site visits involved interviews and classroom observations.

I wanted to do a piece of research that would be useful, specifically to the Montessori teachers and administrators who took the time to talk to me on the phone and allow me into their schools, so I tried to ask questions that I thought other teachers would want to know about the use of computers in the wider Montessori community.

After collecting my data, I got a copy of Computers and Classroom Culture by Janet Schofield (1995). In this excellent book, which documents a two year study of computer use in an urban high school, Schofield points out two of the major obstacles to the effective use of computers in the school: (1) traditional classroom practice and culture, and (2) what she calls the “incrementalist view” of teachers. I had observed these phenomena in the corporate world, and decided to address them in this study.

Aside from interviews and observations, this paper will draw on the Schofield study mentioned above, on writings by Montessori, and on studies involving Montessori classrooms. Finally, I will draw on personal experience as a Montessori teacher, a software developer, and a fledgling researcher.

## **Sites**

All the schools contacted had children from three to twelve years of age. Some of the schools had two-year-olds and some went through middle school. Students were predominantly of European descent, and the fact that all the schools were private indicates that students came from middle to upper income families.

All schools in the study were affiliated with the American Montessori Society. While teachers for children 12 and under were usually AMS certified, the middle school teachers I spoke with were not. At the present time, AMS training for Montessori middle school teachers is only available at a training center in Houston, Texas. At the Montessori school where I observed, there are twelve kids in the middle school who share two small classrooms. All the kids in the middle school do work in both rooms, and move freely between the rooms.

Aside from AMS, there are a number of other organizations that train and accredit teachers and with which different schools may be affiliated, including AMI (Association Montessori Internationale) an international organization) and NAMTA (the North American Montessori Teachers Association). Since this study was to be based on only a small number of interviews and site visits, I did not feel that any meaningful comparison of

schools with different affiliations could be done. No attempt was made to visit public or ethnically different Montessori schools for the same reason. A more extensive study might benefit from such comparisons. My experience in Montessori classrooms includes two years in an ethnically mixed Montessori school in Manhattan where parents were funded by the city on a sliding scale. During this time, there were no experiences that I can recall that would indicate that arguments made in this paper don't hold for ethnically or socioeconomically different groups.

### ***Assertions***

Aspects of the Montessori method have been evaluated both positively and negatively by various constructivist researchers, and an intelligent discussion of these criticisms can be found in The Montessori Controversy by John Chattin-McNichols (1992). Since my paper is about computers and the Montessori classroom, I am focusing on the constructivist view of effective use of computers (specifically as presented by Schofield) and comparing practices that result in effective use of computers with practices in the Montessori classroom.

I will argue that while Montessori schools face some of the same obstacles as other schools to using computers effectively, the practice and culture of the Montessori classroom has many affordances for the version of “effective use” that is presented in Computers and Classroom Culture (Schofield, 1995). Obstacles to effective use that are common to Montessori and traditional classrooms will be presented.

I will further argue that most people usually adopt what Schofield calls an “incrementalist view” when looking at their own work. I believe that there are adaptive reasons for doing

so, and give a brief analysis of a Montessorian's incrementalist approach to computers in the classroom and look briefly at how researchers and software stand in relation to effective use of computers in the Montessori classroom.

## **Classroom culture and traditions**

In her chapter on "Computers, Classrooms, and Change", Schofield (1995) names some consequences of computer use in the classroom that were widely found by her and other researchers. However, just as Montessori materials alone do not make a Montessori classroom (Lillard, 1996), Schofield (1995) notes that simply having computers in a classroom does not guarantee these changes.

In this section, I will show that Montessori classroom culture is consistent with the computer-supported changes in classroom culture that Schofield (1995) characterized as positive from the constructivist viewpoint. My aim in this section is to demonstrate the readiness of the Montessori classroom for receiving computers, by comparing the Montessori method with aspects of a classroom that Schofield found adaptive in achieving effective use of computers in a traditional public school. Therefore, I avoid drawing on observations of computer use in the Montessori classroom, and the other studies of Montessori classrooms that I reference all pre-date the Macintosh and the PC.

## ***Motivation and Enjoyment***

Students in Schofield's study found computer activities to be much more engaging than other classroom activities. One reason Schofield (1995) gives for this is that the computer activities "provided relief from certain aspects of the school situation that students found aversive--most notably, listening to their teachers lecture" (p. 195).

In The Advanced Montessori Method I, Montessori (1995) observes that "...in our experiment the attention of the little child was not artificially maintained by a teacher; it was an object which fixed that attention..." (p. 120).

One need not infer from this that objects (even computers) are necessarily more engaging than teachers. Some alternative reasons for this observed phenomenon are discussed below. The point to be made here is that engagement was an important issue for the Montessori teachers I talked to when they were considering computer software. Lack of engagement is used as a disqualifier when software is evaluated by Montessori teachers and administrators. Below are reasons given in calls to two different schools for preferring office or reference software over educational games:

"The problem with the educational games is that after a few months, the child's interaction with the game becomes mechanical."

"We don't use many games because we don't think they're really engaging."

One reason that Schofield (1995) offered for the motivating power of the computer is student perception that computer skills will be useful in later life. I didn't interview students on this question (this would be a worthwhile question in a future study), but an

important part of the learning experience in the Montessori classroom is the set of activities referred to as the exercises in Practical Life.

The Practical Life exercises include care of the environment, care of the self, life skills, and social skills (Montessori, 1964). In The Montessori Controversy, John Chattin-McNichols (1992) asks: “If one of the roles of the Practical Life area is giving the child the skills and experiences she will need for daily living in our particular culture, how can the computer be excluded?” (p. 82).

Teachers referred to the “real world value” of computer skills in informal conversation, but this value was referenced as a motivator for teaching these skills, not for learning them, and issue seemed as likely to be important to parents as teachers:

“Parents see computers all around, and they’re computer phobic, but they don’t want their kids to be computer phobic.”

There’s no strong evidence that Montessori kids are motivated to work on computers to enhance their future careers. There were high school kids who mentioned this as motivator in Schofield’s (1995) study, but she questions whether this is a real issue. “Just as believing that exercise will improve one’s health does not guarantee that one will embark upon an exercise regime or enjoy whatever exercise one gets, so believing that computer skills will be useful does not guarantee that students will choose to work with them or enjoy the process” (p. 196).

More likely candidates for motivating factors come from studies by Lepper & Chabay (1985) and Lepper & Malone (1987). They indicate that computer tasks are motivating as they increase challenge, control, curiosity, and fantasy.

## **Challenge**

### *Ability to work at their own pace*

Schofield (1995) sites the self-paced nature of computer work as one of the factors that contributes to a sense of challenge. In my Montessori training, teachers often spoke of the importance of finding the right “match” between a child and a material, both in terms of interest and level of difficulty. In the middle school classroom that I observed, there seemed to be more of a requirement that all children follow a particular learning path than I had experienced in working with younger children.

For example, all the sixth grade children had a math quiz at the same time that required them to decode the names of numbers from an unknown language, figure out the pattern, then figure the next number in the pattern. I did notice, however that each list handed out was in a different language, so no two children were doing exactly the same quiz. A question to pursue here is whether the different lists involved different levels of difficulty that were matched to the child.

Further, all of the children in another grade were assigned reading in To Kill a Mockingbird. There were also assignments in current events and book reading that gave children choices about the particular readings to be done. I’m not sure whether or not this reflects the school’s interpretation of Montessori training for the older child. As Schofield (1995) points out, one of the obstacles to using computers for self-paced work is the pressure that teachers feel to prepare children for standardized tests. I would expect this pressure to increase with the age of the child. Also, given the relatively small number of

Montessori secondary schools (Chattin-McNichols, 1992), one might expect that teachers also feel called upon to prepare children for non-Montessori high schools. If I were to take this study farther, it would be interesting to see how these pressures are dealt with in different Montessori schools, since this is an issue faced by schools in general in trying to make effective use of computers.

### ***Feedback***

The rapid feedback provided by computer software also contributes to a sense of challenge (Schofield, 1995). Feedback is an important component of the Montessori materials. Here is a description of one of Montessori's feedback mechanisms from The Montessori Method (Montessori, 1964):

“Let us suppose that we use our first object,--a block in which solid geometric forms are set. Into corresponding holes in the block are set ten little wooden cylinders, the bases diminishing gradually about the millimetres. The game consists in taking the cylinders out of their places, putting them on the table, mixing them, and then putting each one back in its own place. The aim is to educate the eye to the differential perception of dimensions...

“If he mistakes, placing one of the objects in an opening that is small for it, he takes it away, and proceeds to make various trials, seeking the proper opening. If he makes a contrary error, letting the cylinder fall into an opening that is a little too large for it, and then collects all the successive cylinders in openings just a little too large, he will find himself at the last with the big cylinder in his hand while

only the smallest opening is empty. The didactic material *controls every error*.  
The child proceeds to correct himself, doing this in various ways...” (p. 169)

Montessori then goes on to describe different approaches that children may take to correcting their errors once they have received feedback.

Since most of my observations occurred in a middle school classroom, I didn't have the opportunity to observe children's encounters with this kind of negative feedback, but in my experience as a Montessori teacher, this kind of negative feedback served to put students on notice that it was time to try a new strategy to solve problems, in contrast to the kind of negative feedback that can be taken as an indication of failure (Garber & Seligman, 1980).

In teacher evaluation of software, I did not hear explicit reference to the quality of feedback provided by programs. However, this issue is raised by a Montessori-trained researcher (Chattin-McNichols, 1992) and by developers of educational software aimed at the Montessori classroom (Duell, 1996; MECS, 1995). It could be that teachers did not refer much to feedback because the teachers I talked to preferred more open-ended software (except for typing tutors).

## **Control**

### ***Readily available help from peers and teachers***

In my observation of the middle school Montessori classroom, the children got help from peers and teachers on questions about content and clarification of assignments every time they asked for it, with one exception. Here are some typical interactions:

Student A: (*Looking up from book*) Is “meter” spelled with r-e at the end or e-r?

Student B: It’s e-r, but they spell things differently in England.

Student A: Is adrenaline spelled with an “e”?

Teacher 1: Where?

Student A: At the end.

Teacher 1: Yes.

### ***Control over source and content of help***

In her study, Schofield (1995) noted that when computers entered a classroom, students often gained greater control over the source and content of the help they received.

Students in the Montessori middle school classroom I observed got information and clarifications of assignments from the blackboard, from peers, and from teachers whenever they asked. There was one instance when an incomplete answer was given:

Student X: (*Referring to assigned reading in To Kill A Mockingbird*) What was chapter 17 about?

Student Y: They have trial.

Student X: I know, but I only read half of it.

Student Y: (*does not respond*)

The following exchange also made me think of the issue of control:

Student A: What was our Latin homework?

Student B: We didn’t have any.

Student C: *(From across the room)* Yes, you did.

Student A: Mind your own business. You always worry about other people's work.

Student B: Oh, I remember, we had to do the BC thing.

From the lack of a negative response from teachers or peers, I inferred that Student A's reaction was at least tacitly validated, and that Student A felt entitled to control the source of help she received.

The following is an example of a student getting information from the blackboard and clarification from a teacher:

Student D: *(Walks to blackboard. One of the assignments written on the board is "bring in an outside reading". Looks at Teacher 2).* I have a book.

Teacher 2: Let me see it.

Student D: *(Shows teacher the book)* Shiloh. It won the Newberry Award.

Teacher 2: OK, this is going to stay in school.

### ***Building on success***

Schofield (1995) notes that Whitmore High students using intelligent tutoring software were required to succeed at a given task before moving on to the next task. Montessori (1964) used the idea of ordering tasks according to difficulty, and observing children to determine their readiness to be introduced to progressively more difficult tasks. She also built feedback mechanisms (control of error) as discussed above to help insure that the child could succeed at the task presented.

Here is comment from a Montessori middle school classroom teacher to her students that reflects the idea of mastery before progress at the middle school level:

Teacher 1: (*Handing back quizzes*). Your homework for tomorrow is to fix it, but people who failed have to take it again tomorrow. Anything less than 80% is failing.

Schofield (1995) also mentions that students in a computer science class could often get a simple, if incomplete, version of their program working and then build on this “successful” program. Montessori (1964) designed materials so that children could revisit them at deeper and deeper levels. For example, the binomial cube is a three dimensional puzzle consisting of two different sized cubes and a set of prisms that give a physical representation of the formula  $(a + b)^3$ . The puzzle is introduced to children in the 3-6 year-old classroom. Its full meaning is eventually realized in the 9-12 year-old classroom. So, children can “succeed” at a task on one level, and keep revisiting the task and building on their accomplishments at deeper and deeper levels.

### ***Ability to express negative sentiments***

Schofield (1995) says that students using computers are better able to “express negative sentiments” (p. 198). I’m not sure that I understand her on this point. I don’t remember having any particular trouble in expressing negative sentiments when I was in high school. Children in the classroom I observed had no problem verbalizing their sentiments about the fact that they needed 80% to pass a test:

Student A: Why do we need 80% to pass a math test? We only need 60% for Latin.

Student B: What do you need in public school to pass a math test?

I don't have the teacher's response in my field notes, but I do remember a response being made. Neither the teacher nor the children smiled during the exchange, which further suggests that negative sentiment was being expressed.

Was Schofield referring to the fact that you can call your computer names that you wouldn't call your teacher? I'm not sure that I'd consider this empowering. Maybe I just missed her point.

### *Freedom to leave their seats*

As is typical of Montessori classrooms (Lillard, 1996), there were no assigned seats in the middle school classroom I observed, and students changed location as they went from one activity to another, and one student moved to a location nearer the teacher without changing activities. Students sat in chairs, on the floor, and on pillows.

### *Conclusion*

In this section, the argument has been made that the basic motivational issues raised by Schofield are not foreign to the Montessori classroom. Of course, the underlying assumption in here is that good motivation makes for good learning. Many researchers have argued that this is the case (Anderson, Shirey, Wilson, & Fielding, 1987; Asher, 1980).

On the other hand, Schofield (1995) also points out that students may be highly motivated to engage in some computer activity and learn very little from it. This fact was generally recognized by the Montessori teachers and administrators that I spoke with. One administrator commented:

“We experimented with games at one point. Kids brought them in from home. We found that they were generally quite violent and sexist. We also feel that computer games can lead to a loss in creativity.”

Games at other schools were either banned (as at the school above), or relegated to after-school activities.

A question to pursue from here would be the distinction made by teachers between engagement in some Montessori task (or a “good” computer learning task) and engagement in a computer game like PacMan or Tetris, or an “edutainment” type game like Oregon Trail or Where in the World is Carmen Sandiego?

### ***Teacher’s role***

The change of the teacher’s role in classrooms with computers has been characterized as a shift “from the sage on the stage to the guide on the side” (Schofield, 1995)

Studies have shown that children in Montessori classrooms work independently from the teacher (Black, 1977; Reuter and Yunik, 1973) to a greater degree than in traditional classrooms.

Students in the classroom I observed got information and clarification of assignments from peers nearly as frequently as from teachers (Teachers got four questions on clarification of assignments, and one informational question compared with two clarification and two informational questions between peers). The only small group activities that were verbally initiated by a teacher were two quizzes for two different groups. Although much of the individual activity had been previously assigned, individual activity was initiated in all cases except during the following exchange:

Teacher 1: Do you have something to do?

Student X: I'm reading.

Teacher 1: Then you shouldn't be sitting at the computer.

There was more back and forth discussion about whether Student X should be at the computer, then Teacher 1 sends him to pillow corner.

### ***Changes in peer interaction patterns***

Schofield (1995) notes that the placement of computers in the classroom can affect the level of peer interaction in the classroom. Montessori teachers are sensitive to the placement of materials in their classrooms. Even though Montessori materials are light enough for children to carry from a shelf to any available workspace, careful attention is paid to the placement of materials in the room to facilitate the development of the child's sense of order (Lillard, 1996).

In the Montessori classrooms I observed, computers were placed in a room so that a child using a computer had at least one neighbor whose computer screen was close enough to see

easily by leaning over or moving a chair a little. As indicated by field notes above and by other studies, Montessori children are also accustomed to talking with each other about their work (Black, 1977), teaching peers and learning from them at a high rate when compared to children in other kinds of classrooms (Baines & Snortum, 1973). This was the case in the classroom I observed in spite of the fact that children were not explicitly given group project work. From my own experience as a Montessori teacher, I found that such interaction was encouraged by the fact that children were allowed to move about the room, were allowed to speak to nearby peers, and were not placed in direct competition with each other.

## **Obstacles to change**

In her study at Whitmore High School, Schofield (1995) noted some obstacles to the changes in classroom culture that are necessary for effective use of computers. Most of these obstacles were present in the Montessori schools I visited.

### ***Lack of familiarity***

Many teachers at the schools I contacted are unfamiliar with computers. I did not collect data to suggest whether this is a greater or lesser issue among Montessori teachers as compared with the general teacher population, and this would be a question worth exploring.

Knowledge about the use of computers in classrooms is usually disseminated by one or more knowledgeable teacher. I spoke with one teacher who had been to training and one who might be going in the near future. Both were either the only or one of a small number

of “computer-savvy” Montessori teachers. This matches the pattern observed by Schofield (1995) at Whitmore.

### ***Scheduling***

Even though the Montessori classroom is geared toward independent work (Lillard, 1996), there are scheduling issues that come up, even though they differ somewhat from the schedule problems that teachers had at Whitmore (Schofield, 1995).

In Montessori classrooms, even within the same school, different teachers set up different guidelines as to how long a student may stay on a computer (“some of them can waste an hour surfing on the net”), what they can do on the computer (“the teachers don’t like them to spend school time working on typing skills, especially when they have computers at home”), who can be on the computer (“one teacher requires that there be one computer available for a girl at all times, because girls aren’t getting to the computers”).

There is a qualitative difference between the scheduling problems in the Montessori classrooms and the ones that Schofield (1995) described at Whitmore. When a Montessori student walks over to a computer and sits down, she is still considered a participant in the class. At Whitmore, scheduling problems arose in classrooms where this was not the case.

## From the known to the unknown

### *The incrementalist view*

There was another issue that Schofield (1995) considered an obstacle to the changes that computers could bring to the classroom. She called it the *incrementalist view*. “From this perspective, the goal of computer use is not to facilitate fundamental changes in the goals or methods currently typifying the educational system. Instead, it is to help teachers and students do what they are currently doing more easily, efficiently, or effectively. So, for example, one might decide that rather than having students do worksheets using a pencil and paper, the same time could be devoted to having them use a computer-based drill and practice program that might hold their interest better and reduce the amount of time the teacher spends correcting papers” (p. 104).

As a systems analyst in the 80's, I heard similar remarks about the use of computers in the workplace. It was my perception that things began to change in corporations as programmers became more familiar with work being done in different departments, and managers in different departments became more familiar with computers. This was a process that took place over years, even in companies that had tremendous resources. Early “incrementalist” computer systems were not created by ignorant users alone. They were also created by ignorant programmers, and by ignorant theorists who thought that adequate systems could be built on the basis of interviews conducted by systems analysts. In order for better systems to be implemented, we all had to learn a lot.

Similarly, the use of drill and practice computer programs cannot be blamed on teachers alone. These systems were conceived by academics (incrementing along from

programmed instruction to CAI), and written by programmers (using familiar read-evaluate-print interactions), and in spite of all the talk we might do about paradigm shifts, I suspect that we're all pretty incrementalist at heart, and that big change will only come after a lot of small increments and a lot of cross-communication.

In the first section of this paper, I argued that the Montessori classroom is culturally closer than traditional classrooms to classrooms that use computers effectively. In the previous paragraphs, I argued that researchers and programmers are as incrementalist as teachers. At this point, I'd like to try to represent a Montessori perspective on specific uses of computers in the classroom, based on readings and interviews. A subject for a future study could try to come up with similar characterizations for researchers and software developers. The point of such characterizations would be to understand more deeply the space between these perspectives and how to bridge them. Script/counterscript analysis of discussions between teachers, researchers, and programmers (and maybe administrators, students, and parents as well) might also be helpful here (Gutierrez, Kris, Rymes, Betsy, & Larson; 1995).

In the sections that follow, I will try to present one of these characterizations: a Montessorian incrementalist point of view of computers in the classroom.

### ***What kind of a Montessori material is this?***

The computer is not typical of the didactic instruments in the Montessori classroom. Montessori materials are made so that kids can take them off of a shelf and carry them to a location of their choice, to be near a friend, a teacher, to have a view of the door or a window, or for any reason, as long as no other child's space is invaded in the process. They can't do this with computers. Further, direct manipulation of objects is a key part of

Montessori activities, especially for children aged three to six, but words and images on a computer screen cannot be directly manipulated.

Given the rapid pace of technological progress, one can imagine lightweight VR systems combined with wireless networks that would obviate these problems, but what do we do in the meantime?

The schools I contacted were divided in their concern over the direct manipulation problem. Some felt that no child should use a computer before age 9. Others had computers in classrooms for 3-6 year olds. Others had kids start at age six. There is no agreement among Montessori “experts”, either. In Montessori Today, Paula Polk Lillard (1996) follows the lead of Peter Gebhardt-Seele (1985) in advocating the hands-off-until-age-9 position, while John Chattin-McNichols (1992) suggests in The Montessori Controversy that graphic drawing programs with graphic pad input are appropriate for the 3-6 classroom.

And where should computers be placed in a classroom, given the fact that the child can’t carry them around? Phone responses from Montessori teachers and administrators indicated that computers had their own nook in the classroom. More than half of the classrooms had more than one computer, so I inferred in at least half of the classrooms, it would be possible for a child to sit at a computer and be able to easily see her neighbor’s computer screen by leaning over or moving her chair. This was the case in most of the Montessori classrooms I visited, and was Schofield’s (1995) preferred arrangement.

Internet access also affected the placement of computers. In one school, there was only one wired computer in each classroom, and this computer was placed next to the teacher’s desk to allow the teacher to monitor use of the Internet.

### ***Where does the computer fit in the Montessori curriculum?***

Schofield (1995) stated that typical of the incrementalist viewpoint was an “emphasis on how computer applications fit into the current curriculum” (p. 105), so here we go.

#### **Computer as museum piece**

Montessori advocated a “museum of machines” where students could tinker with and repair everyday machines. It has been suggested that computers would be a logical exhibit for a modern version of this museum (Lillard, 1996).

#### **Computer as practical life material**

John Chattin-McNichols places the computer among the exercises in Practical Life. From this perspective, reasonable activities with the computer might include demonstrations on using the mouse, the keyboard, and other input devices; how to insert and remove a CD; how to change printer paper; how to change a printer cartridge; how to add memory.

A practical life approach to software might include use of graphics software, typing, moving files, creating directories, use of office software, use of networking software (e-mail, chat, Netscape), creating and publishing HTML pages, software installation, and programming. Kids at one of the schools I visited were programming in Microworlds. This was the only school I contacted that had kids programming.

### **Computer as library**

Older children in a Montessori classroom are expected to do research (Polk, 1996). Older children at schools I surveyed used encyclopedias on CD and did searches on the Internet with Netscape as part of their research. There was concern among some teachers that children develop their library skills along with the ability to access resources on the computer. There was concern about making Netscape a research tool at too early an age because younger children have more trouble distinguishing accurate information from inaccurate information presented on the web.

### **File organization as sorting**

Montessori (1995) developed many exercises in sorting. Applications and documents generally appeared to be arranged in a rather haphazard fashion on the systems I examined. It might be an interesting exercise for children to sort applications according to function (reference, communication, programming, tutor, game) and sort documents according to owner and subject matter by placing them in directories.

### **Internet as going out**

According to Polk (1996), “the materials on the shelves lead the children to exploration beyond the classroom walls, out into the community and world beyond: to libraries, museums, universities, parks, observatories, botanical gardens, zoos, concert halls, homes of local residents who are knowledgeable or gifted in a particular field of study, and more.” (p. 58).

In the 1990's, the Internet might qualify as part of the "and more". But another question arose when talking about kids on the Internet: When is a child old enough to go out by herself for a walk in cyberspace?

Polk (1996) describes the Montessori activity of "going out" as a series of exercises that build on each other. Once the child has shown responsible behavior inside the classroom, she may be allowed to go to other parts of school building, then out to the school grounds, then gradually out into the community.

A parallel might be drawn here with the use of Netscape. The child may first use Netscape on a machine that is not wired at all, by accessing HTML files from a local disk. Then, the child might access the web through software that limits her to accessing particular links, then through software that filters out particular links.

### **Internet as conversation**

E-mail or online chat could be used for various language exercises. It can also be used to communicate with local or remote experts "who are knowledgeable or gifted in a particular field of study" (p. 58)

### ***Programmers and Researchers***

Programmers have approached software design for the Montessori classroom in two ways: (1) replication of Montessori materials in computer environments (Duell; 1996), and (2) replication of Montessori presentations in computer environments (MECS; 1995). I didn't see either kind of software in the Montessori classrooms I visited.

Researchers in education seem to have moved closer to Montessori's (1964) scientific pedagogy through the adoption of participant observation and the design experiment (Erickson; 1986). Montessori's own methods of experimentation and observation are not nearly as rigorously defined as those of modern researchers, and there is now a program run by John Chattin-McNichols (1992) to train Montessori teachers in modern research methods. Since the Montessori classroom was designed with participant observation and design experiment in mind, it makes a rich environment for researchers as well as children and teachers.

## **Conclusion**

In this paper, I tried to demonstrate how the culture of the Montessori classroom is conducive to the effective use of computers. I then tried to lay out a snapshot of current use from an incrementalist Montessorian's point of view in order to begin a discussion of the space between current teacher perspectives and perspectives of programmers and researchers. In doing so, I tried to show why I believe that further examination of this space could lead to development of highly effective use of computers more quickly than examination of computer use in traditional classrooms.

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