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ABSTRACT

A study investigated whether computers would enable students to develop individual working writing environments. The programs that the fourth-grade students used were Hypercard, Clip Art, and MacWrite. Students worked with each of the programs and talked about what they were thinking while using the computer. A constant flow of teachers, staff, observers from other schools, interested computer users, and researchers passed through the small computer room. Constraints on students' creativity included technological limitations and the desire to complete a class project. Despite the constraints, students were pleased with their experiences in the computer room. Results also indicated that: (1) students preferred working in a visually stimulating environment; (2) students employed metacognitive processes to learn how to work creatively within the structure of the computer or software; (3) students lacked knowledge of how the computer system worked; (4) the editing and spell-checking capabilities and the readability of the final product made it easier for students to write unimpeded; (5) the main inhibitor for many students was the keyboard interface; and (6) despite distractions, students were engrossed in what they were doing once they opened their working file. Findings suggest that the power of the computer to free students from labor-intensive editing processes greatly enhances the writing process, and that the diversity of activities in the computer classroom environment make it impossible for the teacher to be aware of what all the students are doing, suggesting that individual criteria may be the next logical step in the computer classroom evolution. (Contains four figures of data.) (RS)

Metacognition and Strategic Use of Computers: A Study of Creative Writing with Grade Four Children

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Study for the ITEC Project of UNESCO

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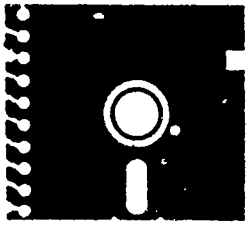

The ITEC Project
Information Technology in Education of Children

FINAL REPORT OF PHASE 1

Documents compiled by
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Division of Higher Education

Introduction

Grade 4 students from Marigold Elementary School were chosen to be observed due to their participation in the Apple Discovery Program. The decision to use an ethnographic approach was based on the belief of the researchers that computers could enable students to develop individual working environments; this belief however makes it difficult to predetermine common characteristics of the student-computer interactions. The programs that the students chiefly used were Hypercard, Clip Art, and MacWrite. Hypercard was used as an interactive multimedia programming environment, Clip Art was used for the animation of existing digitized graphics, and MacWrite was used as a word processor. The students were asked to work with each of the programs and to talk about what they were thinking while using the computer. The interview process took about 45 minutes, while the amount of time spent with each program was determined by the wishes of the students. During the observation time a series of questions that evolved from the various comments and nuances given by the students was developed. Thus, for the first student there were about 10 questions which were thought may be interesting to explore. This is not to say that it was intended to dogmatically pursue the answer to the predetermined questions, rather, it was intended to use them as a template to help keep the flow of information coming from the student.

As more students were interviewed, questions were added and removed as seemed fit based on the following two main criteria: a) that the questions did not intrude on the students' personal lives,

and (b) that the questions were prompted from the interaction between the students and the researcher. If questions did not arise consistently, or if they seemed irrelevant then they were dropped. As well, care was taken to ensure that the questions did not intrude on the interaction between the student and the computer; thus, in many cases, the questions were asked and answered at the end of the observation period rather than during it. At the end of the total interview process a total of 63 questions remained, of which 49 are used directly in this paper. The responses given by the students were then compiled by percentage into groups of common answers. The responses were then compared with personal notes and perceptions, and finally reflected upon based on relative importance, with the main discoveries brought forward in this discussion.

This paper contains five main sections: introduction, class physical environment, class interpersonal atmosphere, metacognitive processes, and discussion and future avenues. Class physical environment will focus on the layout of the computer-classroom. Class interpersonal atmosphere will concentrate on the human interactions. Metacognitive processes will focus on the impact of technology on students' writing skills; and discussion and future avenues will focus on the implications of the findings in this discussion.

Class Physical Environment

The basic layout of the computer class is rectangular, roughly 15 meters by 3 meters. There are two entrance ways at either side

of the ends of the rectangle, with one entrance backing onto the library and the other opening into the hallway. In many respects the room resembles a hallway, although access through the back door to the library is limited. Computer workbenches run along both sides of the length of the room, with usually around 10 computers on both sides. Usually there is enough seating for 30 students.

Since there are very few computers in the students' regular classrooms, the computer room is in a constant state of flux with some classes or groups of students coming and going on a fairly regular basis. As well, there is a constant flow of teachers, staff, observers from other schools, interested computer users, and researchers. The presence of so many people in the lab at any given time results in the lab instructor constantly moving from student to teacher to staff to researcher to computer user to computer. The computers are all backed against the wall. This allows students to turn their backs on the buzzing activity when they wish to concentrate on their projects. If a problem is encountered by students, the many available computer literate people are constantly able to help devise solutions. Hence, even though at first glance the classroom may seem to be chaotic, it is actually a productive and supportive learning environment.

Class Interpersonal Atmosphere

The three main interaction focuses are student interactions, teacher student interactions, and external interactions. Since the computer room at Marigold has so many "techy-gadgets" such as audio digitizers and video scanners, many computer-literate people

from throughout the community come there. These people are from all sorts of backgrounds, ranging from high school students and local teachers from technologically deficient areas to school district administrators, university researchers, and computer hackers who just need to use some of the equipment. As these people float in and out, they serve as a resource for all, and ideas and information are constantly being exchanged. The greatest impact that these external people seem to have is their effect on the students' perception of the relevance of what they are doing. That is, the students tend to feel that they are not working in an isolated, information-deprived classroom; rather, they are part of a very exciting, evolving world in which technology plays an essential role.

The teachers who are involved with implementing the computer-based learning environment are as elated about using the computers as are the students. However, a struggle exists between their traditional role of the teacher as a disseminator of a body of knowledge within a controlled environment, and the teacher as a facilitator, that is, the determiner of how much structure is needed to enable the students to control their own avenues of exploration without cramping their individual needs and styles. The general approach toward structuring the learning environment has been to provide instruction in the regular classroom on new techniques that may be used in different computer programs, providing goals for the students, then allowing them to tackle their objectives in the computer room. Overall, such an approach seems to be quite effective. Most students were able to quickly master and apply the new techniques.

While there has been success in empowering the students with the required skills needed to use the computer effectively, there are constraints placed on the students' creativity due to the environments of the programs they have been using, and the solutions devised by the teacher to hold the class together. The constraints imposed by the programs are due to the limitations of the programs and the technology. As an example, students would imagine a picture they would like to create on the computer screen and discover that it could not be drawn the way they wished. The causes for the students inability to draw the desired picture usually stemmed from a lack of a high enough monitor resolution, a lack of animation capabilities of the computer program, or a lack of authoring tools provided within the program package. Constraints placed on the students by the teacher were primarily due to the apparent need to produce class projects. While the students were allowed to work on their own projects, they were not neccesarily part of the evaluation process, and therefore did not play an essential role in providing parents and students with feedback.

The most evident constraint, that resulted from both the limitations of the technology and the desire for a class project, appeared during the development of a class newspaper. The program chosen for the project was Hypercard, and four main topics about which to write were chosen; people, science, sports, and tales. The first letter of each topic formed the name of the paper *PSST*. Although in itself the process of making the paper was not particularly constraining, problems arose with the amount of space allotted to each topic. The average amount of space provided was 6

centimeters squared. This limited the students 'writing to about 20 words. Although this space was sufficient for students who did not particularly enjoy writing, the students who did enjoy writing found it not big enough and tended to feel like they were obliged to complete a frustrating task. Although this constraint was clearly not what the teacher had intended, it still existed. The problem primarily stems from attempting to provide a working environment that is useful to an entire class, rather than to an individual.

Despite the constraints, which were really quite few and possibly due to the lack of guidelines on how to let students assume command of their own learning, students were definitely pleased with their experiences in the computer room. Even though the lab instructor's time was in constant demand by many people, thereby disabling him from devoting a lot of time to individual student's needs, the students were constantly busy. If students were stuck on a problem they readily asked their friends or another person that they thought might know a solution to the problem If people in the room could not find a solution, which was very unlikely especially over the long term, then 75% (Figure 1) of the students would either start working on a different project or keep trying. Only 25% (Figure 1) of the students said they would give up entirely on those occasions when there were no forthcoming answers.

Another key component in the interstudent interactions was the boot up time, or time it took for the students to load a program and log onto the system. On average, it would take the entire class about 10 minutes to log on, with individuals taking from 30 seconds up to the full 10 minutes. The cause for the variation was due to the

nature of the system program, which requires each student to log on one at a time. During the boot-up time, teachers actively promoted the reading of appropriate books, so as to not have the children waste time. Student preference at these times was to socialize or just look around the room. Once again, due to the activity level of the room, most students found it difficult to concentrate on their books. However, once the computer was logged on they would enthusiastically start their work.

There are two probable explanations for why the students were able to concentrate while working on the computers instead of reading. Perhaps the students simply wanted the boot-up period as a socializing time. The idea of reading a book at that time was devised by the teacher, perhaps as an attempt to reduce an apparent lack of productive activity. The students felt that the reading period was an inconvenience with 84% (Figure 1) preferring to do something other than read. Another possible explanation, which learning theorists have been suggesting, is that the new generation of children are more visually literate as compared to their text literacy, whereas their parents are just text literate (Eriksson, 1988).

Questions

1) What do you do/think about during boot up time?

Nothing	28%
Think about what to do	24%
Read	24%
Talk	20%
Look at start-up screen	4%

2) What would you like to do during boot up time?

Talk	29%
Nothing	24%
Read	16%

Play a game	12%
Look at a screen	4%
Miscellaneous	8%
Think	8%
Help others	4%
Does not know	4%

3) **Who do you normally learn your computer techniques from?**

Teacher	40%
Students	8%
Self	4%
Lab Teacher	4%
Others	4%
Combinations of the above	40%

4) **How do the different programs appear on the screen?**

Does not know	100%

5) **When you can't figure out what to do, and there's no one to help, what do you do?**

Do something else	48%
Keep trying	28%
Quit	24%

Figure 1. Information Sources.

Metacognitive Processes

Visual Processes

One of the most interesting metacognitive processes evident in the students is their visual literacy. There is little doubt, based on the results of this study, that the students preferred working in a visually stimulating environment, as 92% (Figure 2) of the class liked doing animations. Although the animation skills were new to the students, 28% (Figure 2) said they were already making stories for their animations. Although 68% (Figure 2) said they were not plotting stories for their animations, it appeared as though they were, as most animations had themes. For example, one girl who had said that she did not think she connected stories to her animations

had created an animation of baby turtles emerging from their eggs, then moving to the sea. It is probable that many students did not think that their animations were stories because they did not fit the established definitions of story. When asked if one sentence could be a story, 76% (Figure 2) said no, with the following three key explanations: it would be too short, it would not say anything, or a story is not a sentence.

Questions

1) Could a story be just one sentence?	
Yes	20%
No	76%
Not sure	4%
2) Why/why not?	
It would be too short	44%
Depends on content	16%
It would not say anything	12%
A story is not a sentence	12%
Does not know	8%
If the sentence had all the ideas it would be ok.	4%
3) Do you like doing animations?	
Yes	92%
Sometimes	4%
Not Applicable	4%
4) Why/why not?	
They are fun to do	92%
The product looks neat	4%
Not applicable	4%
5) Do you make up stories to make an animation for?	
Yes	28%
No	68%
Not applicable	4%
6) Do you connect your written stories to your animation?	
Yes	24%
No	72%
Not applicable	4%

Figure 2. Visual Aspects.

Structure versus Creativity

The answers the students provided tended to be based on definitions that were provided them by adults. The limitations placed on what a story could be were indicative of the fact that the resource people involved with computers were very knowledgeable about computers, but, they also had specific boundaries of creativity within which they worked and made decisions. Thus, in people's efforts to empower the students so they may take full advantage of the medium of the computer, they inadvertently created fences for the students creativity.

Other metacognitive processes the students were employing related to learning how to work creatively within the structure of the computer or certain software package and understanding how the computer and software work. A computer will only do what it is told to do, and, in order for this to occur some level of understanding how the machine works is invaluable. This leads to a major dilemma facing the teacher. Should a teacher spend time discussing the abstract workings of a computer, or get the students to start working immediately with the teacher filling in the gaps later? The method chosen at Marigold was the latter. It is probably the most effective approach, despite its limitations.

There is one prime limitation imposed by not understanding the system that had an impact on the students metacognitive processes. This is, the need to memorize series of events without knowing why those steps are being taken. For example, the steps involved in logging on followed by loading the appropriate program

and then opening the desired file was usually a 10-step process. Memorizing 10 steps, which actually change depending upon where the program or file was stored (harddrive or internal drive), proved to be too much for 100% (Figure 3) of the students. Students consistently demonstrated varying degrees of frustration as they tried to open programs or locate their files. They usually had to resort to asking an instructor how to get their file. This was clearly due to a lack of understanding of how the system works. Yet, if a lot of time was spent on explaining how the system worked prior to using it, many students would probably lose interest and ignore the explanations.

The lack of student knowledge about computer systems could be seen in several ways. No one knew any of the physical processes required to enable the programs to appear on the screen. Ninety-two percent (Figure 3) could not explain what a computer system was, and 92% (Figure 3) did not know where software is stored when the computer is in use. It was almost as if the students were working in a "magical land" where things just happened. When asked if it mattered to them how the computer works, the students' attitudes were probably similar to other people's attitudes about cars with over half only being concerned that they know how to make the car work, while only 12% (Figure 3) thought it was important to understand how it works.

1) How long have you been using computers?

Less than one year	20%
One to two years	44%
Greater than two up to three	8%
Greater than three and up to four	8%
Greater than four up to five years	20%

2) **Do you use them outside of class time?**

Yes	64%
No	36%

3) **When do you use them out of class**

At home	20%
After school	20%
Recess / lunch time	12%
No answer	32%
Not applicable	16%

4) **Do you have a computer at home?**

Yes	44%
No	56%

5) **What is a computer system?**

Does not know	92%
A tool	8%

6) **Where are programs in the system?**

Does not know	92%
Guessed a wrong answer	8%

7) **Does it matter to you where programs come from?**

Yes	44%
No	44%
Depends	8%
No answer	4%

7a) **Why/why not?**

Does not know	32%
Just as long as it works	24%
Concerned about getting computer viruses	20%
Just thinks it is important	12%
Reasons of integrity	8%
No answer	4%

4) **How do the different programs appear on the screen?**

Does not know	100%

Figure 3. System Knowledge and Use.

The Writing Process

Despite the periodic moments of frustration, the students were very engrossed in what they were doing once they had opened their working file. Once within the "magical" world of the computer their enthusiasm for self expression through writing was clearly visible. The main reason the students enjoyed writing was due to the use of the computer to eliminate most of the tedious components of writing. Instead of the children focussing their efforts on the mechanics of how to print letters, the children were able to concentrate on the content of what they were writing.

There were essentially three ways that the computer made it easier for the students to write unimpeded: editing, spelling, and readability. The editing capabilities of the computer enabled the students to write freely without fear of mistakes that would require a lot of effort at the end to correct. Thus, students would happily type their stories with the knowledge that if they made a mistake, or felt like changing a component of their story after having written them, they could easily make the corrections and changes. It is likely that due to the apparent ease of these changes, 68% (Figure 4) of the students said they wrote to explore ideas, that 80% (Figure 4) said their stories evolved as they wrote rather than making up the story then writing it down, and that 68% (Figure 4) said they changed their stories. While editing features of the computer enhanced the students flexibility of story content, the spell checking feature helped students to overcome fear of using words they did not know how to spell.

Spelling words correctly was very important to 92% (Figure 4) of the students primarily because they were concerned that other

people must be able to read their stories. Instead of stopping and pondering over the spelling of words, thereby interrupting their trains of thought, students would continue to type their stories. When they felt their stories were done, 80% (Figure 4) said completion was based on when they ran out of ideas and 80% (Figure 4) would then check for spelling errors. These spelling errors were easily corrected due to the editing features of the computer as well; 60% said it is easier to see misspelled words on the screen. Of the 64% (Figure 4) of the students who used the spell checking feature of the computer, 55% (Figure 4) felt it helped their own spelling primarily due to the computer's ability to show the correct spelling immediately. In comparison, to their own work however, some students felt the dictionary took too long, and that one had to know how to spell the word in the first place. Instantaneous answers to questions of mechanics prevented students from loosing interest in editing, thereby, enabling them to produce very readable stories.

Questions

1) Do you think of a whole story first and then write, or do you write and think at the same time?

Write and make story	80%
Story first	12%
Both	8%

2) Do you allow yourself to write, to explore ideas?

Yes	68%
No	28%
Depends	4%

3) When do you feel your story is finished?

Run out of ideas	80%
Loses interest	8%
Mistakes are corrected	4%
Does not know	4%
When there is a lot written	4%

4) Do you think a story has to have an ending?

Yes	28%
No	72%

5) Do you check your work for mistakes?

Yes	88%
No	12%

6) When do you look for mistakes?

When finished the story	80%
During writing and when finished writing	20%

7) Why do you look for mistakes?

So others may read it clearly	52%
To avoid trouble with the teacher	12%
The story is not finished until mistakes are corrected	8%
Gets another student to check	4%
Likes to be able to spell	4%
No answer	20%

8) Do you change your story sometimes?

Yes	68%
No	28%
No answer	4%

9) Why do you change your story sometimes?

Sometimes the story does not sound right	40%
Get a new idea that fits	16%
Does not know	12%
Too many mistakes are made	8%
It's easy to change so why not	4%
Gets an urge	4%
Not applicable	8%
No answer	8%

10) When do you change your story?

While writing the story	48%
At the end of the story	12%
Not sure	12%
When using the computer	8%
Not applicable	8%
No answer	12%

11) Is it easier to see misspelled words on a computer, as compared to handwriting?

Yes	60%
No	28%
Neither	12%

11a) Why/why not?

Easier to see	56%
Does not know why	16%
No answer	16%
There is no real difference	8%
Catches mistakes by hand before making them	4%

12) Is spelling important to you?

Yes	92%
No	8%

12a) Why/why not?

So other people can read it	60%
Miscellaneous	28%
Does not know	12%

13) Do you check your spelling?

Yes	88%
No	4%
Sometimes	8%

13a) If so when?

At end of writing	60%
At end of and during writing	24%
If it looks really bad	4%
No answer	8%

14) Do you use spell checker?

Yes	64%
No	36%

14) Why/why not?

It shows mistakes	40%
No answer	24%
Easier than dictionary	12%
Does not know how to use it	12%
It is fast	4%
Does know why/why not	4%
It does not work	4%

15) If you use spell checker, do you think it helps in your own spelling?

Yes	40%
No	16%
Not applicable	28%
Depends	8%
No answer	8%

15a) Why/why not?

It shows errors immediately	32%
Does not know	16%
Miscellaneous reasons it does not	12%
Not applicable question	28%
No answer	12%

Figure 4. Writing Components.

Students felt that the increased readabilty of their written works would enable others to read their stories without being slowed down by poor hand writing. Story readability contributed greatly to the high result of 80% (Figure 5) of the students enjoying reading other students' stories and 76% (Figure 5) enjoying reading their stories to others. Hence, as a result of the computer's capacity to make editing, spelling correction, and readability assesment easier, students felt more confident in writing, more readily willing to show their effort to others, and more able to concentrate on content.

The main inhibitor for many students is the keyboard interface. The one area that slowed students down in their ability to write was their typing skills. Sixty eight percent of the students felt they got more work done on the computer as compared to handwriting. However, of the 32% (Figure 5) that felt they got less work done, 50% (Figure 5) said they were faster at handwriting and 50% (Figure 5) believed that the computer makes mistakes. In all instances it was not computer error, rather, that the students would press the wrong key. In order for students to become significantly unimpeded by the keyboard interface, thus enabling them to concentrate even further on their story content, basic keyboard skills need to be developed. This is not to suggest that the students need to become touch typists. Based on experience, typing levels of

around 20 to 30 words a minute would probably be sufficient to enable the students to communicate with the computer in a manner such that their creative flow is not interrupted (Samuels, Schermer, & Reinking, 1991).

Questions

1) Do you change your story on a computer more often than when writing?

Yes	48%
No	48%
No answer	4%

2) Why do you change your story more often on a computer versus a pen and paper?

Computer is easier	56%
Not applicable	12%
Applicable to reverse question	12%
No answer	12%
Does not know	4%
Teachers forces student to change with the computer	4%

3) Do you put all your ideas into one your story, or do you sometimes leave them out?

All in	32%
Leave out	68%

3a) Why/ why not?

Would not make sense to leave all in	32%
Miscellaneous answers	28%
Does not sound right	16%
Does not know	16%

4) Do you like what you have written when your done?

Yes	80%
Depends	20%

4a) Why/why not.

Just likes it with out reason	72%
It is finished	8%
Does not know	8%
An accomplishment	8%
Likes writing	4%

5) Do you feel you get more done working on the computer?

More	68%
Less	32%

5a) **Why/why not?**

Faster at handwriting	20%
Computer errors are too frequent	20%
Computer is faster	16%
The computer is less tiring	12%
It just seems like the computer is faster	12%
Does not know	8%
Easy to read from computer screen	8%
Easier .to correct mistakes	4%

6) **Do you make more mistakes on the computer than doing things by hand?**

Yes	36%
No	52%
Depends on what is being done	12%

Discussion and Future Avenues

The events that are happening in Marigold school appear to harbour great promise for future students and educators. The diversity of activities that are found in a computer-classroom environment make it impossible for the teacher to be aware of what all the students are doing in their individual computer based efforts; which suggests that individual curricula may be the next logical step in the computer-classroom evolution. Such a direction may be desirable when one considers some of the metacognitive advantages that are associated with a computer-classroom

The computers' power, of freeing the students from the relatively labour intensive editing processes of using a pen and paper, greatly enhances the writing process. Students develop a greater sense of freedom to change their original stories, which encourages them to spend more time concentrating on higher level thought processes.

It is important to note that the level of activity found in the classroom would most likely diminish significantly if all schools had

the equipment that is available at Marigold. The number of researchers and computer hackers and other interested people would drop off, which may have an impact on the level of the students' enthusiasm for their projects. The true impact of the novelty of the computer center can only be determined over time. It is quite concievable that after a few years of computer use, interest could wane and the computer would become just another tool. Much of the students' enthusiasm for the computer is based on the perception that they are working on their own projects, thus it seems reasonable to suggest that in order to maintain the students' level of interest flexibility of computer use will have to be maintained.

As students become more computer literate and start delving into some of the more powerful potentials of computers such as accessing databases, classrooms may be transferred into a highly stimulating, interactive and information rich environment. Based on the experiences in Marigold Elementary School, the development of such a classroom environment would be dependent on several steps. Three key steps would be: a) to promote the concept of having teachers act as facilitators rather than front of the room presentators; b) to provide students with access to a greater variety of equipment such as modems and databases, and c) to alter the current perception of the need for a common curriculum and a comon system of evaluation.

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