Presented at the CRIDALA 2000 conference, Hong Kong, 21-25 June, 2000

Minimally Invasive Education for mass computer literacy

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Abstract
In two experiments conducted in India, PCs connected to the Internet were provided on the roadside and turned on without any instructions or announcement. In both instances it was seen that the acquisition of basic computing skills by groups of children was achieved through incidental learning and some minimal (human) guidance.
This paper reports the observations and compares the two experiments, suggests steps to further the experiment and discusses the new pedagogy. It also suggests a methodology for replicating the experiment.

Introduction

Use of the Internet is spreading rapidly in India, as it is in the rest of the world. While the users in India are, almost entirely, restricted to the affluent in metropolitan areas, it is more than likely that demand for the Internet will eventually arise throughout the entire country. In this context, there are many apprehensions from academicians and others that the ability to access and the quality of training provided will hinder the usage of Internet in the subcontinent.

We think this may not be true and report the results of an experiment in Internet and computer usage using a "minimally invasive" (we borrow the term from surgery!) approach to learning.

Background

The ability to access the Internet is one of the most important factors in the use of computers today. In many forums held on the subject in the Indian Subcontinental region, We have found people questioning the utility of schemes that rely on the Internet. The argument proposed is that there are too few people in the region who have access. In my opinion this argument is not a good one for deciding on whether or not to start activities in this area. We base this opinion on the fact that resources have seldom affected the spread of a medium in this region. For example, India produces the largest number of films in the world. While it may be argued that in a country that is known for extreme poverty, people would rather spend on food than on films, in reality this is not the case. Films are watched in every corner of India by millions of people irrespective of their social or economic status. In fact one might argue that the virtual world that is offered by films is sometimes the only relief that the poor have from a harsh, and often unbearable, reality.

While telephone connections in India grew from zero to 4 million in 40 years (1950-1990), cable TV connections grew from zero to 16 million in just six (1990-1996). I would once again propose that this is due to the value perceived in entertainment over other "essential" items. In a study conducted by the Department of Electronics, Government of India, some years ago, it was found that many rural areas ranked a colour TV set as more essential than, say, clean drinking water. Such is the power of media.

Most lay users perceive the Internet as a source of information and entertainment. The cost of acquiring a PC and an Internet connection at home is about Rs. 70,000 (US$ 1600). In addition there is a recurring cost of the phone bill of about Rs. 10,000 (US$ 135) every year. In a country where the average annual income is about Rs. 6000, these amounts are not small. The fact that the home PC market is growing at 44% seems to indicate again that the economics of entertainment in the region are not clearly related to incomes.

We would expect that explosive growth in Internet usage would take place in the region, regardless of any other factor.

Minimally Invasive Education

Hypotheses

The idea of unsupervised learning was first pointed out in a paper on the use of diagnostics (debugging) as a learning tool (Mitra, S. and Pawar, R.S., 1982). Of the work done later in this period, two experiments are worth mentioning in the context of this paper. Both experiments were based on a paper (Mitra, S.,1988) where it was suggested that unsupervised use of computers can lead to accelerated learning of skills in children. It is now widely felt that children are more adept at modern computing skills than most adults, although they seldom want or get formal education in this area.

The first experiment on the use of computers in rural India was conducted by Marmar Mukhopadhyay in the village of Udang in the state of West Bengal in India (Zielenziger, 1995). Here, a few computers were placed in a school and children allowed to use them after minimal instructions. Word processing, spreadsheets and database management systems were readily learned by both teachers and students who then went on to create a rural resources and healthcare database.

The second experiment was conducted as a set of courses for children in NIIT Limited, an Indian training company with over 150,000 students. These experiments were called LEDA (learning through exploration, discovery and adventure) and were based on a publication (Ahuja et al, 1995). The structured use of computer games for meeting learning objectives was the key strategy. Once again, it was observed over a period of four years that skill training would happen automatically in children given enough access and motivating content.

In view of the above suggestions and experiments, we propose the following hypothesis:

The acquisition of basic computing skills by any set of children can be achieved through incidental learning provided the learners are given access to a suitable computing facility, with entertaining and motivating content and some minimal (human) guidance.

Theoretical foundations for the hypothesis

The world of education is coming up with new movements, frameworks and theories to explain how learning occurs or how it should be conducted. Each has passionate supporters and detractors who debate on the effectiveness and inherent appropriateness of one over the other.

Broadly, however, almost all teaching-learning interactions can be classified as one of the following:

- Those where the teacher or external resource determines the learning content and methodology.
- Those where the teacher or external resource determines the learning, in consultation with the learners.
- Those where the learners determine their own learning outcomes and how they will go about it.

The last of these encompasses theories such as Piagetian, situated cognition and constructivism.

Constructivism theory talks about cognitive growth and learning. This theory has gained many adherents in recent years (c.f. Forman & Pufall, 1988; Newman, Griffin, and Cole, 1989; Piaget, 1973; Resnick, 1989;Vygotsky, 1978).
One of the foundational premises is that children actively construct their knowledge rather than simply absorbing ideas spoken at them by teachers. It posits that children actually invent their ideas. They assimilate new information to simple, pre-existing notions, and modify their understanding in light of new data. In the process, their ideas gain in complexity and power, and with appropriate support they develop critical insight into how they think and what they know about the world.

The two specific features of this philosophy borrowed from research in child development, is that play and experimentation are valuable forms of learning (c.f. Daiute, 1989; Garvey,1977; Herron & Sutton-Smith, 1971). Play involves the consideration of novel combinations of ideas. It is a form of mental exploration in which children create, reflect on, and work out their understanding.
Both play and exploration are self-structured and self-motivated processes of learning.

Another growing body of research on collaborative or cooperative learning has demonstrated the benefits of children working with other children in collective learning efforts (Johnson, Maruyama, Johnson,Nelson, & Skon, 1981; Rysavy & Sales, 1991). When children collaborate, they share the process of constructing their ideas, instead of simply labouring individually.

The educational application of the above theories lie in creating curricula that matches and also challenges children's understanding, fostering further growth and development of the mind.

Experiments:
Our experiments are based on the Constructivist approach. In two experiments conducted in India, one PC was placed in Kalkaji, New Delhi, so that people in and around that area (which is mostly slums) could explore and experiment at their own convenience. A similar experiment was repeated in the town of Shivpuri, Madhya Pradesh.

This paper reports the observations and compares the two experiments, suggests steps to further the experiment and discusses the pedagogy. It also suggests a methodology for

replicating the experiment.

In this hypothesis, basic computing skills are defined as the ability to turn on and operate a personal computer in a common GUI environment such as Windows. It is possible to develop a list of tasks that the learner should be able to perform. This would be the traditional method for measuring the skill level of learners. However, we choose not to develop such a list. In the present computing environment, developing such a list would be inappropriate and may not measure the skill levels reached since, the list itself may have to be changed too rapidly due to changes in technology for any measurement to be meaningful. We, therefore, propose a task-oriented method for assessing skill levels.

Initially, we will define a computer literate child as one who can:

1. Turn a PC on
2. Use MS Paint to create a designated picture
3. Move objects using folders, shortcuts, cut-and-paste, drag-and-drop, copy and delete methods.
4. Move from one web page to another and back.
5. Send and receive e-mail through a PC that is pre-configured to do so.

The Udang experiment

Mukhopadhyay's experiment at the village of Udang in Howrah, West Bengal, India has been widely reported (see, for example, Zielenziger, 1995).

In this 1995 experiment, a PC was installed in the village high school. While the intention was to train teachers and then students in basic computing literacy, it was observed that students and then teachers, very quickly acquired the necessary skills and began to use the PC to set up a local database. Since the PC was not connected to any network or the Internet, the concept of electronic communication did not emerge in the learners. However, the experiment was considered a success and the village now has a training centre for computing, the first and among very few rural areas in India to have such a facility.

The Kalkaji experiment

This experiment was conducted to find out whether:

1. Potential users will use a PC based outdoor Internet kiosk in India without any instruction.
2. A PC based Internet kiosk can operate without supervision in an outdoor location in India.

Location and construction of an outdoor kiosk

An outdoor kiosk was constructed such that it could be accessed from outside the boundary wall of the NIIT headquarters in New Delhi. As a result, the experiment is often referred to as "the hole-in-the-wall experiment". The campus is situated in Kalkaji

in the extreme south of the city. The office is bordered by a slum, as is the case in many Indian cities. The slum contains a large number of children of all ages (0-18), most of whom do not go to school. The few who do go to government schools of very poor quality (that is, low resources, low teacher or student motivation, poor curriculum and general lack of interest). None are particularly familiar with the English language.
The kiosk was constructed such that a monitor was visible through a glass plate built into a wall. A touch pad was also built into the wall (see photo 1). The PC

Photo1: Children examining the kiosk on the first day.

driving the monitor was on the other side of the wall in a brick enclosure (see photo 2). The PC used was based on a Pentium, 266 Mhz chip with 64Mb of RAM, suitahle hard disk, a true color display and an ethernet card. It was connected to NIIT's internal network of 1200 PC's using the Windows NT operating system. The kiosk had access to the Internet through a dedicated 2Mbps connection to a service provider.

Photo2: Construction of the kiosk housing on the office side of the wall.

Observations

The kiosk was made operational on the 26th of January, 1999. It was turned on without any announcement or instruction. A video camera was placed on a tree near the kiosk in order to record activity near the kiosk. Activity on the CPU was monitored from another PC on the network. This enabled the kiosk to be monitored and, if necessary, controlled from within the office. We monitored activity through the day and took notes or other actions when necessary.

Children were the first users and they were able to start browsing within the first four hours of use. Detailed observations are reported later in the paper.

The Shivpuri experiment

Shivpuri was selected as the next site for the experiment since it is a semi-rural setting but with telecommunications facilities and Internet connectivity.

Photo3: The first user at Shivpuri

Photo4: An hour after installation, children fight over computer usage in Shivpuri, India.

The results obtained in Shivpuri were in some ways similar to those obtained at Kalkaji. However, there were significant differences as well.

In what follows, we will compare a summary of the two experimental observations.

Summary of findings

Installation, construction and hardware resources available: The Kiosks are Pentium multimedia PCs with only the monitor and the touch-pad (built into the wall next to the monitor for user input) visible to the user.	
Kalkaji	*Shivpuri*
Installed on Jan 26, 1999 about 25 feet from the first house of a slum, facing a large vacant lot. The Kiosk overlooks a footpath travelled frequently by the slum dwellers and anyone using it as a shortcut. Access is from outside the boundary wall of the NIIT office Kiosk housed along a wall, in a brick construction inside the NIIT compound in a small, enclosed, but not sealed area. The wall faces west and gets extremely hot in the afternoon sun (over 45 degrees centigrade) . However, the PC seems to perform adequately without air-conditioning.	Installed on May 4, 1999 within a Govt. Middle School compound directly opposite Shivpuri's main bus stand. The Kiosk is about 50 feet from and visible from the main road that sees thousands of locals and travellers everyday. Kiosk housed in one of the school rooms, with one window being used for the display, and the others boarded up.
Full time 2 MBps Internet connectivity. No keyboard (except when there was a direct intervention for Front Page, for a few users, see later)	No Internet access for the Kiosk users. Occasional keyboard use (as and when the caretaker was present at the Kiosk)
Perceived Environment and Access: Both kiosks offer easy access to anyone walking past.	
Kalkaji	*Shivpuri*
The Kiosk is in neutral territory. It has no association with the slum nearby except that the vacant lot in front of it is used as a public lavatory. However, we have seen all kinds of people using the Kiosk, including children from affluent families (who have a computer at home). The Kiosk is easily accessible to all the people who live nearby (in the slum bordering the NIIT wall, residential colonies of Kalkaji and Govindpuri) and people who use the footpath in front of the Kiosk as a shortcut (includes hundreds of school children, labourers, office goers etc)	Although the Kiosk is inside a school compound, the general area has a slightly unsavoury reputation for gambling amongst the middle and upper-middle class families of Shivpuri. However, this seems to deter only over-protected children and girls from using the Kiosk. The Kiosk is easily accessible to all the people who live nearby, shop-owners of the bus stand area, children of the middle school where the Kiosk has been set up, people passing by the bus-stand not in a hurry to catch a bus.

Regular users, their backgrounds, and usage patterns

(as observed in July 1999)

Kalkaji	*Shivpuri*
The regulars are very young children (age 6 to 12) who live in the slum right next to the Kiosk. Almost all the boys in this age group are users, but only some of the older girls frequent the Kiosk. The majority are at the Elementary school level (below Grade VIII). They all go to some school (either the govt school or 'Ready Go Welfare School' nearby).	The regulars are older teenagers (age 13 to 19). There is little or no overlap in the regular users' ages for the two kiosks. They are mostly at the senior school level (grade IX and above), but once the Middle school reopens (July 5th) the pattern might change. The schools they go to are the Govt No.1 and No.2 schools in Shivpuri.
Other users include older children and teenagers from the slum and the surrounding colonies. None of the adults or parents of these children seem to be making any effort to use the Kiosk.	Some middle school children and some of the people (20+) employed in that area (in the shops around the bus-stand) make up the rest of the users. In the 4 days that the Kiosk was under detailed observation, there weren't any female users (adults or children) at all.
None of the regulars have had a prior exposure to computers except for Sanjay, who has done a basic course on computers from IGNOU.	Most of the teenagers have had a minimum exposure to computers since they are taught 'computers' in school. However, it is unlikely that they have worked before with a multimedia Internet PC. A few have a much better idea of how to use a computer because of having played computer games.
Most used from 9 am to 11 am or so (during the summer vacations), and after 3 or 4 pm till about 8 or 9 pm (kids go away early, the older users stay late)	Most used from 11 am to noon (may have been earlier if the Kiosk had been opened regularly at an earlier time), after 4.30 or 5 pm until shutdown time (usually 8 pm)
Most users spend 1 hour or more in a go (taking turns of course).	Most users (with the exception of one or two) spend about half an hour on any activity.
The Kiosk is very high priority for the younger kids. This is part of their daily schedule. The slightly older kids treat it on par with or	The Kiosk is a priority only as far as entertainment goes. It is not a regular feature except for a couple of people. However, this observation was made during the summer

slightly lower than other games (eg cricket).	vacations and may not be accurate. The older users came often from their work, whenever they had time to kill.
Motivation	
Kalkaji	*Shivpuri*
The Kiosk is like any plaything with the additional advantage that it has a lot of variety. The primary motivation for the younger children is to play with it and figure out things on it so that they can do more with it. We feel the extensive media coverage may have a subtle influence on the children (using the Kiosk is seen as a desirable activity by the world)	The teenagers are well aware of the job opportunities involved and want to learn computers. Computer courses are expensive so this is one of the reasons why they come to the Kiosk. Interestingly, there seems to be a friendly rivalry between the No.1 and No. 2 schools and doing well at the Kiosk is a small part of this as well.
Most popular uses and what they would like to do: At both Kiosks, games are extremely popular. Both sets of users also expressed the desire to see movie clips on the computer.	
Kalkaji	*Shivpuri*
Browsing the web – particularly the Disney Web site where they love playing Games, and navigating stories and cartoons. Also use the web to read news, horoscopes and short stories. The Hindi news sites are popular as are some Bollywood sites. Paint is VERY popular. Almost everyone has used it to make pictures or write their own names – in fact seeing their own name on the computer is a big attraction at both Kiosk locations. They like playing songs (mp3), but that's usually to provide background entertainment. A few of the kids have started learning how to use Front Page Editor and are making basic web pages with text and images. They use a combination of character map and other applications to write their name.	There hasn't been web access for a while now (none except at the beginning), so no browsing. Songs are the biggest priority and the power of Bollywood (the facetious name for the Indian film industry) is evident. Everyone who comes to the Kiosk first reaches for the songs directory and plays them. Movie clips, even if only 25 seconds long, are extremely popular. Did not see anyone use Paint on their own until it was left open on the desktop or a shortcut to it was made on the desktop. Using DOS to create own directories and small extensionless files (with one or two lines of text, and in one case two 5 digit numbers which could only have been phone numbers, in a file called "Neha"). A couple of users have started creating basic web pages (after intervention) in Front Page, for making advertisements for their 'Comics and Video Game Centre'.
Since the users are younger, they would like to do anything which is interesting especially	Would like to browse the sites that they can see links to but can access. Some of the more

video clips.	aware users want to start using email and 'learn' computers in the sense of using applications. Don't know if they have any idea of working on programming. Would also like to take printouts.
Competencies Achieved: All the users have achieved a working knowledge of the Windows operating system and can use the pointing device to point and click in order to select, and double-click to open. They can play songs using WinAmp and launch applications such as Paint and Word but their styles of working differ.	
Kalkaji	*Shivpuri*
Use of the right click for properties (and to create new objects folders and shortcuts on the desktop). Click and drag to move items and create shortcuts. Keep trying to select different menus/ menu items and know most of the standard ones and how to use them (Example: use the Undo, Cut, Copy, Paste options in the Edit menu or the File…Save As). As a result know small features such as Set as Wallpaper in Paint or Explorer. Very comfortable with idea of cut/copy and paste but maybe not the fact that it happens throughout the interface (i.e. can cut-paste across applications). Using Character Map application to insert text into other files. Using Find in the start menu to find files but without any specifications (in fact, someone used Find *.* in C: and picked out charmap.exe from amongst the thousands in the search results). While some of the brightest lot do understand the folder hierarchy, others don't understand it. They also don't try to name the folders (they don't have a keyboard and haven't yet figured out how to copy-paste into dialog boxes). They realise that files have to be 'saved' to be available on the machine and do a 'save as' but since they don't change the name 'untitled', Paint files are often overwritten. Do not have to have new content all the time	None or very little right click use. Click and drag only being used in Paint rarely where the pencil will not draw otherwise. No idea of how to do multiple selections in Explorer/Dialog boxes. Use the menus but only a few options such as Undo, or New in File. Are not trying most of the options in the menus. As a result, are unaware of a lot of the capabilities of the applications. Do not know or understand the idea of copy/paste very well. Perhaps sporadically but not as a general rule. No use of Character Map at all. Have no way of using text if no keyboard is present (a virtual keyboard was installed only recently which pops up a keyboard on the screen and can be used to enter text using the touch-pad alone). No use of Find or any of the other tools. Can change screensavers and background from the Display Settings. Know that ctrl+alt+del restarts the computer (from their prior exposure). Understand the folder hierarchy and are able to find things inside them. Have to have new content all the time. Even if an activity has not been 'mastered' they would rather move on to something else. Are able to edit a web page in the browser, and can delete pictures, lines of text.

(there was a period of about 4 – 5 days when there was no net access, but everyone still used Paint quite happily).	
Prefer to create a bitmap object first and then open it so that paint is launched automatically. The object is what is manipulated.	Prefer to go through the Start menu to Programs to start a particular application and then say New inside it to start making something. The process seems more important than the object. Is this a function of their developmental stages?
Learning Process	
Kalkaji	*Shivpuri*
In general, a trial and error approach is followed. Not afraid of clicking anything new or following any link. Usually press left and right buttons on a new button, or link or whatever. Very good memories – one kid remembered the entire sequence of frames on one of the Disney site visual stories. As a result, are able to remember the steps that they followed to get to a particular thing and repeat them. Are not very good with English (are ok with decoding the letters and pronouncing them but very little comprehension). But are still able to match phrases with events and get by quite comfortably. Have a large amount of patience – can spend a long time getting something just right in Paint. Peer tutoring is happening with Sanjay as the main resource.	In general, the approach is to do the things that they already know about or have learnt about earlier, probably because they don't want to get things wrong. Thereafter, if there is a need to do something, for example, make a piece of text bigger or smaller, then only do they experiment with different buttons, or menu items. Are better at reading English and can often match words and phrases with actions (example, Exit will close the program). However, this is true only for the school going users. The others still work by matching patterns. Not as patient; seem to get frustrated more easily. However, this is probably because they don't have as many 'interesting' things to do. When they are doing something worth while – such as creating a small web page or a picture or figuring out a game, they take their time. Peer tutoring is happening with the Goyals being the main resources.
The children have developed their own terms to describe the objects and events that they encounter while working on the Kiosk. While the applications and web sites are referred to by their names, the arrow cursor is called a *sui* (needle, in Hindi), the crosshair is called a *kaanta*, *daabna* is clicking (Hindi equivalent of pressing, but no distinct terms for left/ right/ double clicks), *sabse rangeen button* for the Start	No special user language was observed. The reason for this could be that some of these users have had prior experience with using computers and are carrying over the terms from there. Other newer first generation users overhear these terms and naturally start using them.

button on the taskbar, *damroo* for the hourglass icon, *kaam kar raha hai* when the hourglass rotates, *macchar ki dawai (insecticide spray)* for the spray tool in Paint. The touch-pad is called just that because the kids overheard the observers and caretakers use the term before they had a parallel term of their own.	
The children are friendly with the observer / caretaker, but tend to work more independently. Only when the other person has been established as some kind of authority is he/she asked for help.	The tendency is to ask a caretaker or observer (if present) what to do at every step. More wary of not getting it right the first time.
Changing Perceptions	
Kalkaji	*Shivpuri*
On the first day, they thought it was a video game being put up for free. Most of the very young children tried it out on the very first day. One of the slightly older (about 11 or 12) ones stayed away initially because he thought it would cost money to use.	Similar reaction on the first day. People afraid of using it because they thought it would cost money or someone would order them away. Once they were told that it was put up for anyone to use, they started using it.
Initially felt that the Kiosk was basically a TV on which there were channels with programs coming at them. Now since they have been playing games and making things of their own, there is the feeling that it can do a lot more and act as permanent storage.	It is strange that low quality movie clips are popular, considering that a TV usually has better sound and image quality. Perhaps their prior exposure to non-multimedia computers makes them treat this as a special thing. Or else it may be the interactivity which is missing in a TV. Now they are able to accept the computer as something which can do a lot of things, rather than just process text.
Community reaction	
Kalkaji	*Shivpuri*
The adults don't try to use the computer citing reasons such as "We don't know the language", "We don't know how to operate it" etc. One elderly lady asked if it would provide food for them. Parents in general felt that while they could see no need for the Kiosk, it was very good for the children.	People generally feel it is a good idea but that guidance is needed otherwise the children will not know what to do and 'misuse' the Kiosk. Some also feel that the location is not right because of the undesirable elements who frequent that area. Some of them do say that it should be locked up regularly to prevent vandalism. Although

	no adults have come forward, one of the older teenagers has said that he is willing ensure that the keyboard is used properly if he is put in charge of it.
Vandalism	
Kalkaji	*Shivpuri*
Initially none, even when the older kids from the govt school nearby came to use the Kiosk. Since May 31st, the touch-pad was damaged 3 times in 21 days. This was happening almost always on a Sunday. The regulars say that it is the older kids who are doing the damage. However, based on what some of them have said, it seems some of the very young children have also been scratching and smashing the touch-pad out of frustration when the Kiosk was not working. So that they would not take the replacement of the touch-pad for granted, we boarded up the Kiosk for a few days (from June 22 to July 7, 1999). We hope this closure combined with a talk with the children about taking responsibility for the Kiosk will work.	The mouse was stolen once (pulled out from inside the Kiosk through the opening for the keyboard). Another time the touch-pad wire was cut. According to Pankaj, he saw people pulling out the keyboard, trying to pour concrete pieces into it, and pushing in small sticks. However, since then, there hasn't been any damage to the computer as such (the door to the room was broken once by some overenthusiastic child while Gagan, the caretaker was inside). The keyboard is never kept outside unless the caretaker is present because that is the most easily damaged part of the computer.

Incidental Results

Kalkaji and Shivpuri:
Familiarity with English words because of associations was observed. For example, realising that 'Quit' means to stop doing something because clicking on it leads to closing the program.

Kalkaji:
- Improved vocabulary due to games such as Pluto's Boneyard at the Disney Channel site.
- Enjoyment of creative activities such as drawing which are treated as boring when conducted in school (possibly because there is much more freedom at the Kiosk and more interesting tools).
- Creation of a divide on the lines of 'Knows and Know-nots' rather than the traditional 'Haves and Have-nots'. There is also a new pecking order depending on ability of using the Kiosk rather than age or physical strength.

- More friction among the users (and even their parents) because there is a greater demand for the Kiosk now as more children learn how to use it, while the 'supply' has remained the same.
- Children have become used to media attention and although they are still excited about a shoot, it is not a big deal any more. All the coverage might affect their motivation and reasons for working on the Kiosk.

Shivpuri:

- Kiosk being used as a place to practice and try out the things learnt in school by the School children.

Intervention: Web Page Authoring

After three months of leaving the children on their own with the kiosk, we decided to teach them Microsoft FrontPage. The idea behind it was that they could all make their web pages and put it on the net.

Day 1
just chatted with the children, asked them about Internet. took names of 10 volunteers who will learn and then teach the other children(mixed age-group). explained that we will be building a home page so they should collect information on what they would like to put on the web page.

gap of 2 days

Day 2
most of them had collected information and made a rough design of their home page
told the children to design their home page on chart paper.

Day 3
Saw the charts all the children made. They made their home page 'children.htm' each one wrote his/her name in it. told them to make their images in paintbrush on the kiosk.

Day 4
Children inserted pictures and text to make a home page. Also noticed them using mp3 smoothly to run songs in the background while they made the pages in FrontPage. we explained to the nearest two and those two explained it to the other children.
Girls complained that the boys don't let them use the computer so they could not make their images.

We gave a gap of three days.

Day 5
The children had now on their own learnt to add images and text.

A week after

Another gap of a week and we noticed that the children had started making web pages on the kiosk. They even learnt how to insert text in FrontPage without the keyboard. Most of them like to put their names and some pictures in it. The other text that they had planned (about their colony, number of people etc) could not be put because of the language barrier. While they wrote all this in Hindi, they could not type in English.

Proposed method

Based on the above experiments and observations, we propose the following "Minimally Invasive" approach to the development of mass computer literacy in the developing world.

The Internet, entertainment and minimally invasive education

The Internet with its limitless capacity to entertain, educate and connect people together will definitely form the basis of new pedagogies for learning. The approach that our experiments seem to suggest is that based on free access and minimal intervention. We call the approach Minimally Invasive Education, MIE.

The MIE model

Certain common observations from the experiments reported above suggest the following learning process when children self-instruct each other in computer usage:

1. One child explores randomly in the GUI (Graphical User Interface) environment, others watch until an accidental discovery is made. For example, when they find that the cursor changes to a hand shape at certain places on the screen.
2. Several children repeat the discovery for themselves by requesting the first child to let them do so.
3. While in step 2, one of more children make more accidental or incidental discoveries.
4. All the children repeat all the discoveries made and, in the process, make more discoveries and start to create a vocabulary to describe their experience.
5. The vocabulary encourages them to perceive generalisations ("when you right click on a hand shaped cursor, it changes to the hourglass shape for a while and a new page comes up").
6. They memorise entire procedures for doing something, for example, how to open a painting program and retrieve a saved picture. They teach each other shorter procedures for doing the same thing, whenever one of them finds a new, shorter, procedure.
7. The group divides itself into the "knows" and the "know nots", much as they did into "haves" and "have nots" in the past. However, they realise that a child that knows will part with that knowledge in return for friendship and exchange as opposed to ownership of physical things where they could use force to get what they did not have.

8. A stage is reached when no further discoveries are made and the children occupy themselves with practising what they have already learned. At this point intervention is required to introduce a new "seed" discovery ("did you know that computers can play music? Here let me play a song for you"). Usually, a spiral of discoveries follow and another self instructional cycle begins.

While this approach is specifically for the learning of computing skills, our experiments and results suggest that the method can be easily adapted for many other subjects as well. Using kiosks instead of classrooms and collaborative, minimally invasive instructional methods form the core of the MIE model.

Outline of the MIE approach

The MIE (Minimally Invasive Education) approach would involve exposing the learner to the learning environment without any instruction. In the case of computer literacy, the learner should be provided with a multimedia computer connected to the Internet.

If the target group of learners are from the economically disadvantaged segments of developing societies, it is proposed that access should be through open, public Internet kiosks, such that learners do not need to "enrol" or take any kind of permission to use the facility.

Kiosk design and engineering

Considerable care needs to be taken in the construction of outdoor kiosks, particularly in tropical climates. The following factors were taken into consideration for designing the kiosks in the two experiments above. Both kiosks survived a severe North-Indian summer without maintenance or air-conditioning.

- Define primary users (keep in mind who they will be and who will benefit most)
- Glare on display needs to be avoided (build kiosk with monitor facing north-east, or between buildings so that there is no direct sunlight)
- Reputation of the area should be acceptable by a large range of people.
- There should be a reliable caretaker (perhaps from the community itself)
- A strong enclosure to prevent break-ins or damage to the Kiosk is required, brick and mortar housing is recommended.
- Software for remote monitoring of kiosk health is required.
- Sensors to detect overheating and humidity should be provided along with software such that the PC can report its environmental data when queried over the Internet.
- Positive pressure should be maintained within the enclosure to prevent dust accumulation. This can be achieved through a set of fans controlled by the PC.
- A sturdy joystick or a touchpad protected by a cowl should be used instead of a conventional mouse.
- The multimedia and network capabilities of the PC should be used to protect it against possible vandalism. The PC should be capable of detecting misuse and of

warning the perpetrator using voice. It should, autonomously, be capable of reporting misuse or damage to a Webmaster.

Internet access

Internet access should be provided through a leased line. Dial-up connections are not recommended due to frequent disconnections and the resultant disappointment to learners.

Wireless connectivity would be the ideal method for outdoor kiosks, if suitable technology is available.

Internet access is considered to be an essential component in the MIE approach to computer literacy.

Instructional design

Instructional design for the MIE method is determined by two factors:

1. The points in the learning process where intervention is required or desirable.
2. The nature and duration of the intervention.

Intervention points can be detected by monitoring learner progress. Such points occur when the learner is observed to have reached a plateau and is doing similar tasks again and again. At this point intervention consists of a demonstration of some new application or capability of the PC followed by discovery learning by the learner. Another type of intervention point occurs when learners are seen to be collectively developing an incorrect concept. At such points, the instructor needs to point out the incorrectness of their understanding through demonstration, and not through direct instruction. This should be followed by a phase of rediscovery, if necessary guided by an instructor.

MIE requires teachers who are adept at constructivism. Such teachers are generally not easy to find, however, the strength of the method lies in the fact that one such teacher can guide many more students than in the conventional system. This is due to the short duration of interaction required in the MIE approach.

Evaluation of outcomes

Outcomes should be measured only in terms of the capability of a learner to perform certain tasks. In MIE the understanding of each learner maybe somewhat different depending on their learning styles and capacity. Therefore, measurement of understanding will not be a correct measure of their capability to use computers.

Summary of activities proposed

Based on the above discussion, we feel that the following activities should be undertaken to further understand and deploy the MIE method.

General steps to be taken:

- Increase the number of Kiosks at a location and see if that reduces the vandalism. This may also result in faster learning due to the 'competition'
- Find more content for the internet kiosk – Hindi email, Hindi search engine, encyclopaedia, reference sites, fun stuff like VRML, other games, more music… decide a good resource/content package – keep refining it.
- Design a good start-up package of content which can be put on a non-internet Kiosk as well.
- Find a way of giving net access or at least updated content to a Kiosk which doesn't have 24 hr net access.
- Develop a set of guidelines for a caretaker, such as instructions on maintenance, what to do in case of problems etc.
- Install and observe a Kiosk at one more location, in a rural set up (metropolis and very small town already done).
- Find a way to remotely monitor, configure and maintain a kiosk in a remote location so that interventions for learning or for corrective purposes can be made at the required times.

Further planned interventions:
- Connecting with other Kiosks or other computers through email/chat
- Greater use of text
- Aiding conventional learning
- Image Editing –art beyond Paint
- Experimenting with Sound/Movies
- Games which build cognitive skills
- Putting the users in control – some kind of programming (such as HTML or other similar applications)

The roadmap should be reviewed and modified after, at least 4 such installations.

Conclusion

Computer literacy need no longer be a privilege of people who are educated and can afford computers at home or at their workplace. The experiments conducted in Kalkaji and Shivpuri support the above statement.

Children are found to be the prime users of street Internet kiosks. They learn to operate as well as play with the computer with minimum intervention. They pick up skills and tasks by constructing their own learning environment.

This perhaps is the learning paradigm of the information age.

Acknowledgements

No experiment of this nature can be carried out without the active involvement of many persons. In particular, the observations described above were recorded by Sujai Kumar, Renu Ahuja and Ritu Dangwal. The kiosk construction and maintenance was carried out by Vivek Rana, who made several innovations in the process.

The experiments were funded by NIIT Limited.

References

- Ahuja, R., Mitra, S., Kumar, R., Singh, M., Education through Digital Entertainment - A Structured Approach, , Proc. XXX Ann. Conv. Of CSI, Tata McGraw Hill, New Delhi, pp 187-194 (1995).
- Brown 1996: Roberts A Brown, The Case for Linear Instruction Design and Development: A commentary on Models, Challenges and Myths, Edducational Technology Vol XXXVI No. 2 Mar-Apr 1996 pp. 5-23.
- Collins, A. (1990). The role of computer technology in restructuring schools. In K. Sheingold & M.S. Tucker (Eds.), Restructuring forlearning with technology, p.29-46. NY: Center for Technology inEducation, Bank Street College and the National Center on Educationand the Economy.
- Collins, A., Hawkins, J., & Frederiksen, J. R. (1991). Three differentviews of students: The role of technology in assessing student performance (Technical Report No. 12). New York, NY: Center forTechnology in Education, Bank Street College of Education.Daiute, C. (1989). Play as thought: thinking strategies of young writers.Harvard Educational Review, 59(1), 1-23.
- David, J.L. (1990). Restructuring and technology: Partners in change.In K. Sheingold & M.S. Tucker (Eds.), Restructuring for learning withtechnology, p.75-89. NY: Center for Technology in Education at BankStreet College and the National Center on Education and the Economy.
- Dede, C. Imaging technology's role in structuring for learning. In K.Sheingold & M.S. Tucker (Eds.), Restructuring for learning withtechnology, p.49-72. NY: Center for Technology in Education, BankStreet College and the National Center on Education and the Economy.
- Forman, G., & Pufall, P. B. (Eds.). (1988). Constructivism in the computerage. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.
- Frederiksen, J. R., & Collins, A. (1990). A systems approach toeducational testing (Technical Report No. 2). New York, NY: Centerfor Technology in Education, Bank Street College of Education.Garvey, C. (1977). Play. Cambridge, MA: Harvard University Press.
- Johnson, D. W., Maruyama, G., Johnson, R., Nelson, D., & Skon, L. (1981).Effects of cooperative, competitive, and individualistic goalstructures on achievement: A meta- analysis. Psychological Bulletin,89, 47-62.
- Kolderie, T. (1990). How structural change can speed the introductionof technology. In K. Sheingold & M.S. Tucker (Eds.), Restructuringfor learning with technology, p.91- 103. NY: Center for Technology inEducation at Bank Street College and the National Center on Educationand the Economy.
- Mitra, S. and Pawar, R.S., (1982). Diagnostic Computer-Assisted-Instruction, a methodology for the teaching of computer languages. Sixth Western Educational Computing Conf., Nov., San Diego, USA.

- Mitra, S., (1988). A computer assisted learning strategy for computer literacy programmes., presented at the Annual Convention of the All-India Association for Educational Technology, December, Goa, India.
- Newman, D., Griffin, P., & Cole, M. (1989). The construction zone: Working for cognitive change in school. New York: Cambridge University Press.
- Piaget, J. (1973). To understand is to invent. New York: Grossman.Resnick, L. B. (1989). Developing mathematical knowledge. AmericanPsychologist, 44, 162-169.
- Riel, M. (1990). Building a new foundation for global communities. TheWriting Notebook (January/February), p.35- 37.
- Ringstaff, C., Sandholtz, J. H., & Dwyer, D. (1991, April). Tradingplaces: When teachers utilize student expertise in technology-intensiveclassrooms. Paper presented at the annual meeting of the AmericanEducational Research Association, Chicago.
- Rysavy, S. D. M., & Sales, G. C. (1991). Cooperative learning incomputer-based instruction. Educational Technology Research andDevelopment, 39, 70-79.Soloway, E. (1991). How the Nintendo generation learns. Communicationsof the ACM, 34(9), 23-26, 95. Herron, R. E. & Sutton-Smith, B. (Eds.).(1971). Child's play. New York: John Wiley and Sons.
- Strommen, Erik F. (1992). Constructivism, Technology, and the Future of Classroom Learning : Children's Television Workshop, Bruce Lincoln, Bank Street College of Education,
- Vygotsky, L. S. (1978). Mind in society: The development of higherpsychological processes (M Cole, V. John-Steiner, S. Scribner, & ESouberman, Eds.). Cambridge, MA: Harvard University Press.
- Wolf, D., Bixby, J., Glenn III, J., & Gardner, H. (1991). To use theirminds well: Investigating new forms of student assessment. Review ofResearch in Education, 17, 31-74.
- Zielenziger, M. , (1995). Logging on in backwater, San Hose Mercury News, Monday, June 12,

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