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A model of how children acquire computing skills from "hole in the wall" computers in public places.

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ABSTRACT

This paper explores the possibility of constructing a "minimally invasive" learning model from the results of a GUI Icon Association Inventory (devised by Dangwal and Inamdar (Mitra.S, 2003)).

We discuss the results obtained from four playground ("hole in the wall"), computer kiosk sites in southern India, made freely available to children, without supervision, for nine months.

Computing skills acquisition, as measured by the Icon Association Inventory, was plotted for each month and the learning curves are reported in the paper. The observed curves were fitted to predicted curves to understand the rates and stages of learning.

Results indicate uniform improvement in the computing skills of the children who used these kiosks.

INTRODUCTION

In India, and in other developing countries, a combination of several socio-economic factors has created a divide between those who have access to basic healthcare and education, and those who do not. It is expected that the ability to access and use computers would help close this divide. However, people in most of India do not have access to and cannot use computers. Although it can be argued that providing computers in every school can bridge this "digital divide", low enrolment, high dropout rates and teacher shortages make the school-based solution to computer training non-viable.

A country like India needs a cost effective approach since IT sector has emerged as a significant contributor to exports earnings (Sood, 2003). By providing IT training to economically disadvantaged sections of society the increasing demand for skilled employees can be met. While this paper deals specifically with computer-skills training, information and communication technologies also offer innovative and interesting tools to improve teaching and learning more generally. As a result, the integration of ICT, both as a tool and as a subject, in educational policies and programmes has become a priority in both developed and developing countries.

Minimally Invasive Education (MIE) experiments were designed to providing students with easy access to computers. The term "minimally invasive" has been borrowed from Minimally Invasive Surgery (MIS) and intervention in learning, so far, has been in the form of providing children with relevant hardware and software (MIE Users Manual, 2003).

The case for MIE is based on many studies, which indicate that children benefit simply from exposure to computers as they use it for multiple purposes. Clements (1999) observed that computers give children opportunities that cannot be offered in the physical world. In other words, technology offers children unique intellectual experiences and opportunities. Children have the opportunity to complete a given task on their own and thus they have the chance to develop their thinking skills (Papert, 1980).
A review of published research into use of ICT by young children suggests there are many areas of education where technology can benefit learners (Kulik1994, Finegan and Austin 2002, Clements 1999).

Among the benefits noted were improvements in mathematical problem solving and in the area of language skills such as vocabulary, reading and spelling. In addition there are references to increased social development and improved social interaction. Because these studies tended to focus on aspects of language or mathematics, they do not report on improvements in young children's technological skills and knowledge (Jones, 2003).

Cognitive research suggests that playing computer games can be an important building block to computer literacy because it enhances children's ability to read and visualize images in three-dimensional space. Sounds and graphics gain children's attention and appropriate software engages children in creative activities. Studies investigating children's knowledge and understanding of ICT suggest that children can acquire effective computer skills through exploration. Downes (1999) studied children's experiences with computers in the home. She found that they developed a range of skills through exploratory activities.

Exploratory learning is at the heart of Minimally Invasive Education: "The Minimally Invasive Education (MIE) approach involves 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"(www.niitholeinthewall.com). Field observations and reports show that children are acquiring functional computer literacy this way. It is also possible that there are other forms of incidental learning that is taking place. Cappelle (2004) studied the impact of MIE learning stations on the children and found that the children did acquire basic computer skills by "sharing their knowledge with each other".

Learning in MIE environment takes place through a play way approach. In a study Begona Gros (2000) maintains that games can enhance the motor development, affective development, intellectual development, and social development. Though the pace of development might be different, depending on the resources at a child's disposal. Again the socio-economic background the child is coming from governs the access to these resources. The MIE pedagogy aims to bridge the digital and resource gap without entailing any burden on the communities. The necessity to offer cheap (i.e. unsupervised) learning environments can be turned into a virtue in the context of a learner-driven, exploratory learning pedagogy.

According to Dr. Mitra (2001), generally speaking, 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 Piaget's, Situated Cognition and Constructivism, which in turn match the MIE approach. Constructivism theory in the field of education talks about cognitive growth and learning. Many authors have worked with this theory in past decades (Piaget 1973, Vygotsky 1978, Forman & Pufall, 1988; Newman, Griffin, and Cole, 1989; Resnick, 1989). One of the foundational premises of this is that children actively construct their knowledge rather than simply absorb 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. Piaget stressed the holistic approach to learning. A child constructs understanding through many channels: reading, listening, exploring, and experiencing his or her environment. As Mitra (2000) explains, the MIE experiments are based on the constructivist approach.

The experiments we report on in this paper examine learning of basic computing skills without any direct intervention by adults, with children aged 8-14. This approach emphasizes a self-directed and participatory

mode of learning in an open informal environment. A child acquires the ability to use and understand technology outside the classroom and thereby is not restricted by the school curriculum. The design and environment allows children to participate or work in groups and learn to observe and deal with technology.
Based on this approach, the experiments consisted of providing computers to children in safe public locations such as a school playground. Through such computer kiosks we provided access to state-of-the-art personal computers to several thousand children in urban and rural India. The computers were placed outdoors, usually mounted on walls and, hence, often referred to as "Hole-in-the-wall". The goal of these experiments is to try and establish a model of education that can reach the hundreds of millions of economically disadvantaged children in rural and urban settings (Mitra, 2003; Cappelle et al, 2004). MIE could be relevant for spreading universal literacy, e-literacy and general education.

The first experiment was conducted in 1999, when one PC was placed in a wall facing towards a slum in New Delhi. An outdoor kiosk was constructed so that it could be accessed from outside the boundary wall of our office in New Delhi. The headquarters of NIIT Limited is situated in Kalkaji in the extreme south of the city, close to a slum. In this slum live a large number of children of all ages, most of whom do not go to school. The few who do attend, go to government schools of very poor quality (that is, low resources, low teacher and student motivation, poor curriculum and general lack of interest). None are particularly familiar with the English language.

The kiosk was constructed in such a way that a monitor was visible through a glass plate built into a wall. A touch pad was also built into the wall. The PC driving the monitor was on the other side of the wall in a brick enclosure. The PC used was based on a Pentium, 266 Mhz chip with 64Mb of RAM, suitable hard disk, a true colour display and an Ethernet card. It was connected to NIIT's internal network of 1200 PCs using the Windows NT operating system. The kiosk had access to the Internet through a dedicated 2Mbps connection to a service provider. There was no keyboard; instead the touch pad was the only input device.

Figure1: Children examining the kiosk on the first day

On the day we installed the device, children from the slum many of whom had no formal education at all, came over to check out the computer. There was no instructor on call; they were left to themselves. Within five hours, one of them, Rajender, eight, had managed to find a Disney site. Within days, a group of children, aged 5 and 17, had figured out how to download Hindi-film hits, Disney movie-clips and cricket trivia.

Not all used the Internet. One little girl used a graphic software to help her father, a tailor, figure out the design and colour scheme of a skirt he was working on. Most of the children played games. They learnt how to use most of the common functions on a PC like cut and paste, drag and drop, copy, paste, rename and save files and so on.

The children also developed their own language for working on the computer because there was nobody to explain the terminology to them. Children invented their own vocabulary to define terms on the computer, for example, "sui" (needle) for the cursor, "channels" for websites and "damru" (Shiva's drum) for the hourglass (busy) symbol.

"*When it appears, the children know the computer is working on something.* In most of our classes here at NIIT, we spend time teaching people the terminology and such. With these children, that seems irrelevant*", (Dr Sugata Mitra, head of research at NIIT, in:* Mitra, S. 2000).

The Minimally Invasive Education (MIE) experiment was based on Mitra's hypothesis (Mitra, 1988) that children can learn to use a computer on their own. Research conducted over five years (Mitra, 1998; 2000, 2001, 2003, 2004) substantiated this hypothesis that "*groups of children when provided appropriate resources will attain computer literacy with minimum intervention*" (Mitra 1988).

Currently (October, 2004), 90 computers have been placed in 23 locations all over India. We are measuring computing skills of these children, but also any change(s) in their academic performance (Inamdar, 2004), their behavior, perception of parents, teachers etc. as a result of public, unsupervised access to computers. This paper discusses the first aspect, the extent of computing skills achieved by the children who have used such computers in four villages in southern India.

CURRENT STUDY

Our study sites are located in the state of Karnataka, in the south west of the Indian peninsula. These sites are in the villages D'Salundi, Kalludevanahalli, Meleykota, and Honnalagere. The educational infrastructure and other important infrastructure in these villages are minimal. These sites were selected on the basis of the structure of the population and the acceptance of the experiments by the local community. This paper reports findings on computing skills for these four sites. The research is ongoing and further findings for all the other sites will be reported and published in due course.

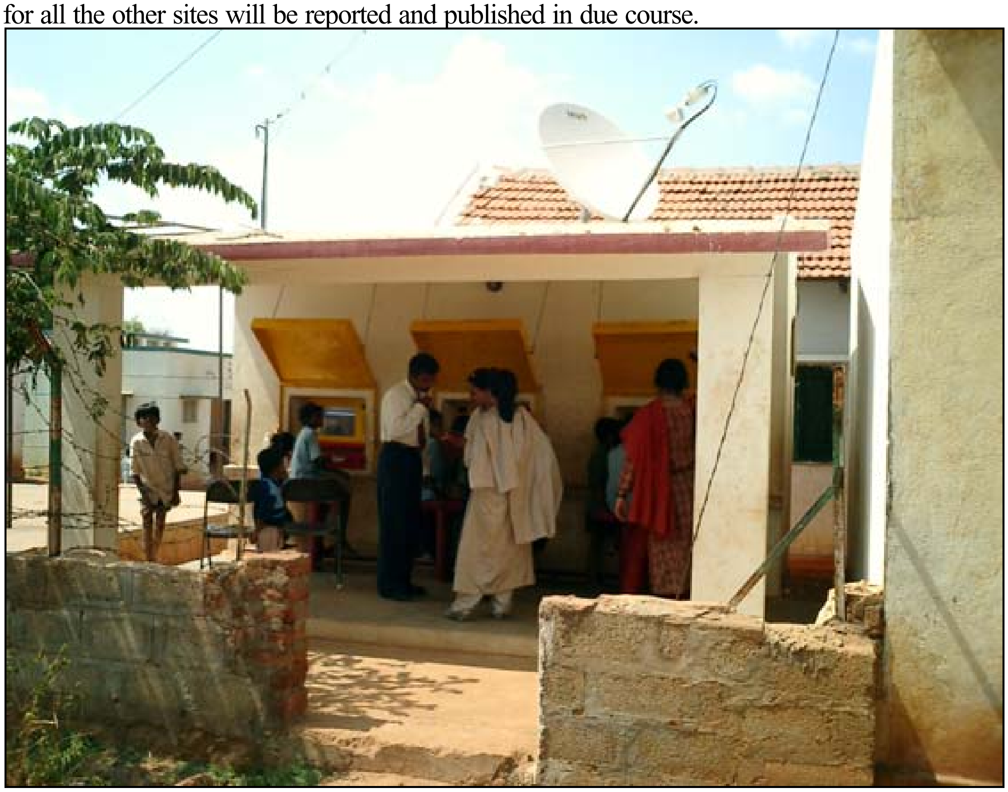


Figure 2: A "hole in the wall" kiosk in Village D'Salundi in Karnataka, India.

OBJECTIVE

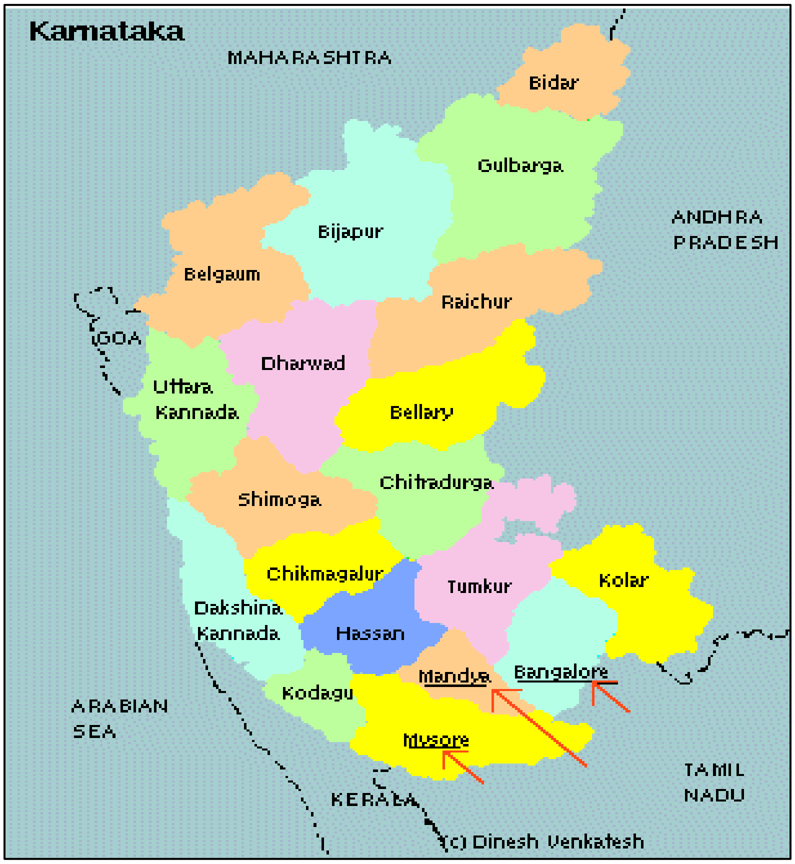
The primary objective of our experiment was to construct a Minimally Invasive Education (MIE) learning model to test the hypothesis that if appropriate resources are provided, children in the age range of 6-14 years can achieve computer literacy.

HYPOTHESIS

"If given appropriate access and connectivity, groups of children can learn to operate and use computers and the Internet with none or minimal intervention from adults" (Mitra 1988).

VILLAGE PROFILE

Figure 3: District Map of Karnataka- the four villages are situated in Mysore, Mandya & Bangalore (two villages are in the Mandya district)



Kalludevanahalli: This is a small village in the Mandya district and is about 40 kilometers away from the main hub.
Geographically, Kalludevanahalli lies east of the Western Ghats in the Indian peninsula. The region's climate is semi-arid but the village receives some rainfall during the monsoon. Most of the villagers are engaged in agriculture and related activities. There is practically no industrial activity, not even small-scale. Since the village lies within a drought-prone area, mainly dry land farming is practiced. The main crops produced are paddy, sugarcane, onion, ragi and coconuts. Seasonal unemployment forces people to work as casual labourers in nearby towns and villages. The villagers also practise dairy farming to supplement their income from agriculture. This particular village has a dairy cooperative which makes it the nodal point for the neighbouring villages. The villagers face problems such as poverty, unemployment and total dependence on the primary sector. It is a patriarchal society where child marriage is still prevalent and caste system still prevails. The social problems faced by the village community are illiteracy, unhygienic living conditions, caste differences, and the dowry system.

D'Salundi: This village is located around 14 kilometres from Mysore (a major tourist destination). Its proximity to Mysore has helped the infrastructural development of this village. According to Ashathnarayan, a member of the Gram Panchayat: "The village of D'Salundi is 250-300 years old and it is called so because the village was planned as a line of houses". The word Salu means "line" and Hundi means "village".
The village economy is agrarian and completely dependent on the monsoon. The main crops cultivated are maize, ragi and vegetables. Monsoon failure affects agriculture severely. To overcome this uncertainty, villagers migrate to work as casual labourers.
The village faces economic problems like poverty and unemployment. Extreme poverty forces parents to send their children to neighbouring cities to work for daily wages. Women also work for wages to supplement the family income.
The village faces numerous social problems. Child marriage is predominant in the village and is one the main causes of high school dropout rates. Schoolteachers have taken some initiative to overcome this social problem through weekly discussions with the community. The dowry system is another social problem- dowry demands are very high and it often pushes the bride's family into a debt trap. Alcoholism is another widespread problem in the village, which causes disturbances at the family and community level.
The village has been included in the MYRADA project (an NGO funded by the EU), which aims at forming self-help groups for women. They have formed various self-help groups called "Sanghas" under the aegis of

MYRADA and Stree Shakthi programmes. These groups provide loans to members; train them in tailoring, basket making and aggarbatti making. These cottage industries ensure some economic stability. At present, there are 20 such "sanghas" which are active in the village.

Meleykota: This village is in Dodabalapur Taluk of the Bangalore district of the state of Karnataka. It is located about 45 kilometers from the city of Bangalore. The village is well connected by road to nearby urban centres. Due to its proximity to urban centres, certain basic amenities like government schools, hospital, veterinary hospital, drinking water facilities, public taps and bore-wells are available. The village has an agrarian economy. In the absence of irrigation facilities, agriculture is dependent on rainfall and is often affected by irregular monsoons. This is the root cause of widespread poverty.
Nonetheless, the quality of life has gone up in recent times, due to a trend towards urbanization. A few of the villagers have found work in the nearby cities. This has been accompanied by certain changes in the social structure. For instance, the joint family system is deteriorating fast and there is a preference towards nuclear families.

K. Honnalagere*:* This village is in the Mandya district of the state of Karnataka. The economy is agrarian. The village has some basic infrastructure in terms of one high school, post office, government hospital, veterinary hospital, bank, and a co-operative society. However, there is widespread poverty as employment opportunities are very limited. Agriculture and sericulture are the two main sources of income. Agriculture is rain-dependent. The main crops cultivated are paddy, ragi, jawar, sugarcane, mango and coconut and mulberry, banana.

All four communities described above depend heavily on agriculture and thus on the level of rainfall. Villagers face economic problems like poverty, unemployment, and poor living standards. For our experiment it was also relevant that people in all four villages speak Kannada as their native language, while English is taught in schools from the 5^{th} grade onwards.

TOOL

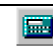
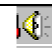
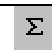
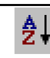
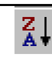
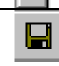
A key tool in the MIE experiment was the Graphical User Interface (GUI) Icon Association Inventory:
An icon in MS-Windows ™ is a small picture or object that represents a file, program, web page, or command. Most of the time, the icon picture relates to the function of the item that it represents (http://www.learnthat.com). We designed the GUI Icon Association Inventory (IAI) to measure the ability of computer users to associate the icons in a Windows ™ GUI environment with their functionality. Children were asked to give a short description in their own language, stating, "*what do they use the icon for*" or *"what do they associate the icon with"*. They were not expected or required to know the formal names of the icons. Past qualitative research (Mitra 2001) has shown that the children associate icons with their functions and form their own vocabulary for naming the icons as understood by them. Keeping this factor in mind the inventory has been made independent of the formal name of the application associated with the icon.

Given below is a sample from the Icon Association Inventory:

GUI Icon Association Inventory (a few items)

Name:	Age:
Class:	Gender:

Here are some pictures that resemble the pictures on the computer. Look at each picture carefully and describe in few words its function.

Test Description

The GUI Icon Association consists of a list of the most commonly used icons in a common computer GUI (Graphical User Interface). This list consists of 77 icons present in the Microsoft Windows and Microsoft Office environment. The icons are divided into six categories namely Desktop (7), Excel (4), Generic (15), Internet (11), Paint (18) and Text Format (22). We provided a glossary containing the correct associations- as expressed by the children, which we later used as a guideline for marking answers and which we updated from time to time. When we later started marking the answers of children to monitor their progress, a score of 1 was given for a correct response and 0 for an incorrect response. The answers were written down in each child's mother tongue (there are 17 languages and several hundred dialects spoken in India) by the individual researcher administering the test- the answers were later graded manually.

Test Validity

There exists another version of the Icon Association Inventory (IAI). In this second version, the test consists of multiple-choice answers for describing each icon and this version can be graded by software.

In their study D'Souza and Mitra (2004) administered both versions of the test and validated against a Task Based Computer Literacy test [TBCL] devised by "Outreach and Extension", University of Missouri and Lincoln University, USA. The TBCL is reliable since it consists of specific tasks (for example, "copy a picture and paste it into a document"), which are carried out by students who are then graded on their performance. A high correlation was observed between all three tests. An example of the correlation between the TBCL and two versions of the IAI is shown in Tables 1.0 and 2.0. The tests were administered to 18 entry-level students to a computer applications course in New Delhi.

As a result, we felt confident applying the IAI pen and pencil version to evaluate the effect of hole-in-the-wall computer kiosks we offered.

Table 1.0: Pearson's Correlations between TBCL and IAI

	IAI	IAI s/w	TBCL
Icon Association Inventory (IAI) -paper pencil	1	0.8476	0.7609
Icon Association Inventory (IAI) -Software	0.8476	1	0.8062
Task Based Computer Literacy (TBCL)	0.7609	0.8062	1

- Signif. LE .05 ** - Signif. LE .01 (2-tailed)

Table 2.0: Kendall's coefficients (W) for comparing the three tests.

	W	p
All three tests	0.95	<0.001
TBCL with IAI (paper pencil)	0.97	<0.001
TBCL with IAI (software)	0.95	<0.001
IAI (paper pencil) with IAI (software)	0.96	<0.001

NB: "p" is the probability of W being non-significant.

SAMPLE SELECTION

At each site location, one month prior to the kiosk inauguration, a local researcher interacted with the community and children in particular. S/he identified a large group of approx. 25-30 children; from these children, the researcher selected 15 children as focus group children. The criteria for selection were primarily that children who lived in and around the kiosk (testing accessibility) and whose parents were forthcoming in sending their children to the kiosk. These children were in the age range 8-14 years.

Three groups of children were selected in each location: the focus group, the control group and the frequent user group. The control group was made up of children who came from similar socio-economic backgrounds and were in the same age range as the focus group children. The only difference was that these children lived further away and thus did not have access to the MIE kiosk.

The frequent users were children from the same village as the focus group and were using the kiosk. The only difference here was that they had never been tested before by the researcher. Exposure to computers or any other technology was similar for the three groups of children.

ADMINISTRATION OF IAI (paper-and-pencil version)

After the selection of the sample groups, we tested the three groups in the following way:

i) *Focus group* – The 15 children that had been selected at random were tested on the first day, the seventh day and then monthly until the ninth month. The first day test results formed a baseline, while the 7th day test results were used to check whether some, often rapid, learning was taking place.

ii) *Control group* – These seven children were only tested on the IAI after nine month. The control group was selected from nearby villages whose socio-economic strata are similar to the focus group. These children did not have access to the MIE kiosk. The reason why the control group was not tested at the beginning of the experiment were concerns that the act of testing would arouse sufficient curiosity for them to get interested in computers more than they would usually be.

iii) *Frequent users* – These were 15 children who were also tested only in the ninth month. These children were chosen to be frequent users of the MIE Kiosk but are not a part of the focus group children. This group was taken to study whether there was any Hawthorne effect[1] on the focus group children who were tested more frequently.

METHODOLOGY

In the original IAI test, there are 77 icons. 26 of these 77 icons, however, did not appear in the pre-configuration of the MIE kiosks These 26 icons include 4 icons from the MS-Excel spreadsheet and 22 text formatting icons from the MS-Word word processor.

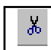
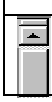
Tests results were therefore based on the remaining 51 of the 77 icons. However, the children were also tested on the other 26 icons, as a way of checking the effectiveness of the IAI in measuring computing skills. The result here was that all groups scored zero in this part of the test over the entire period. This indicates that the children were, indeed, learning the meaning of the icons from the kiosks and not from any other source.
Scores of the three groups, that is, the focus, control and frequent user group, were compared, analyzing the data from the test on the first day and after nine months.

Further, a logistic model is used to study the behavior of performance over a period of time. In non-linear modeling the main aim is to predict the performance at a given time through a fitted model *[Annexure 1].*

SCORING

As mentioned earlier in the paper, the present study uses the original IAI (paper and pencil version) to assess computing skills. This test uses human judges. The children describe the functionality of the icons in their native language (Kannada). If the description of the icon is correct, the researcher administering the test (also Kannada speaking) gives a score of 1 and when wrong or incorrect gives a score of 0. A glossary is given to each of the researchers and whenever in doubt, they would get back for clarification. Cases where the child gave just the name of the icon, a score of 0 is given (see the example given below). The rationale behind adopting such a scoring is to see the extent to which a child understands the functionality of the icon. And only if the child had used the icon, would s/he be able to describe its functionality.

Examples: Children in Kalludevanahalli have given these responses.

	One child saw this icon and wrote “scissors”. He is given a score of 0. Later, the same child when tested again wrote, “*We can cut pictures with this and move them here and there”.* He is given a score of 1.
	One child described this icon as “ *Computer – we get information and songs through this”.* He is given a score of 1
	One child described this icon as *“If we cannot see anything then we should “click” on this “button”, to move the page*”. He is given a score of 1.

RESULTS

Overall Results

[1] Participants performing better on tests simply because they feel, through the act of testing, that they are given special attention. The Hawthorne effect was observed “as an increase in worker productivity produced by the psychological stimulus of being singled out and made to feel important” (Clark, D. 1999). Here, it refers to the focus group children not being influenced by the test itself.

The overall results are reflected in the following diagram and tables: For each village, there is one diagram and two tables

The diagram shows, for all four villages, the percentage scores for various groups of children (i.e. focus, control & frequent users) on the first day and after nine months.

The first table shows the overall - Difference in the focus group performance on the first day and after nine month, i.e. the last day of the experiment.

- The second table shows the overall differences among the three groups after nine months,

The tables list the mean scores in four of the six categories of icons in the IAI (paper pencil). Hence, N in the tables refers to the number of data points, that is, the number of children times four. In other words, in the three of the four villages the focus group consists of 15 children hence the "Number" of children is 45 and in one village i.e. D'Salundi, the focus consists of 10 children. So, the total number of children is N = 55. These children were tested in four categories of icons, hence the data points is 55 X 4 = 220. Similarly, in three of the four village the control group consists of 7 children, hence the number of children = 7 X 3 = 21. And in one village (D'Salundi) the number of children is 6; hence the total number of children consists of 27 (21+6). These children were tested on four categories of the icons i.e. 27 X 4 = 108.

Karnataka (all the four sites)

Fig 4.0: Performance in Icon Association Inventory

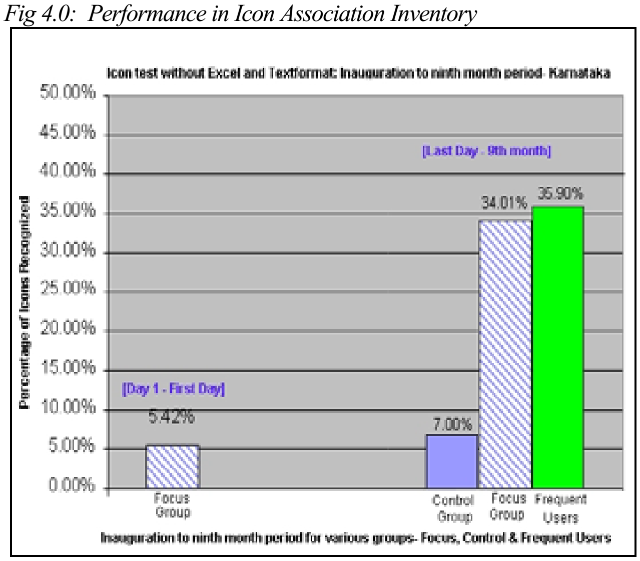


Table 3.0 First day Vs. Ninth Month – Focus group

	Mean	N	Std. Dev	Std. Error Mean	t	Df	Sig.
First day	.69	220	.69	4.62E-02	-18.21	219	.000
9^{th} month	4.34	220	3.12	.21			

Table 4.0 Results in the ninth month (by group)

	Group	N	Mean	Std. dev	Std. Error mean	t	Df	sig
Focus Vs. Control	Focus	220	4.34	3.12	.21	15.275	269.639	.000
	Control	108	.93	.78	7.52E-02			
Focus Vs.	Focus	220	4.34	3.12	.21	1.004	438	

Frequent	Frequent	220	4.62	2.86	.19			.376
Control vs. Frequent	Control	108	.93	.78	7.52E-02	-17.722	280.124	.000
	Frequent	220	4.62	2.86	.19			

Results from individual sites:

The results for each site is reported in the following tables and diagrams: For each village, there is one diagram and two tables

The diagram shows the percentage scores for various groups of children (i.e. focus, control & frequent users) on the first day and after nine months.

The first table for each village shows the difference in the focus group performance on the first day and after nine month, i.e. the last day of the experiment.

The second table for each village shows the differences among the three groups after nine months,

a) Kalludevanahalli

Fig 5.0: Performance in Icon Association Inventory

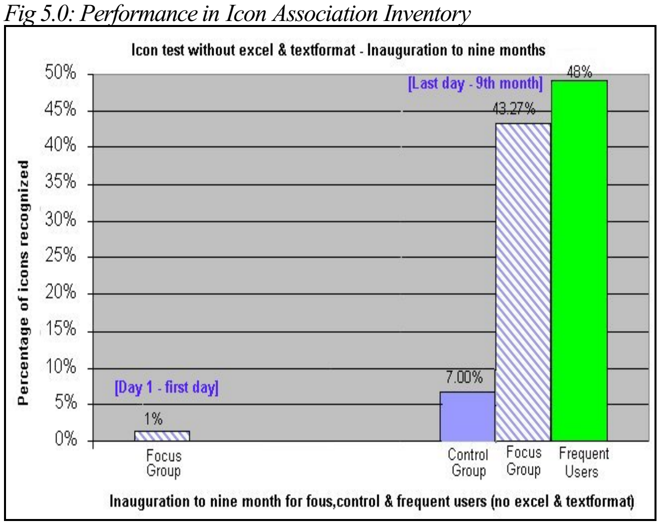


Table 5.0 First day Vs. Ninth Month Results - Focus group

	Mean	N	Std. Dev	Std. Error Mean	T	df	Sig.
First day	.17	60	.38	4.85E-02	-14.636	59	.000
9th month	5.53	60	2.93	.38			

Table 6.0 Results in the ninth month (by group)

	Group	N	Mean	Std. dev	Std. Error mean	t	Df	Sig
Focus Vs. Control	Focus	60	5.53	2.93	.38	11.344	76.213	.000
	Control	28	.89	.83	.16			
Focus Vs. Frequent	Focus	60	5.53	2.93	.38	-1.52	118	.131
	Frequent	60	6.42	3.42	.44			
Control vs. Frequent	Control	28	.89	.83	.16	-11.783	72.355	.000
	Frequent	60	6.42	3.42	.44			

b) D'Salundi

Fig 6 .0: Performance in Icon Association Inventory

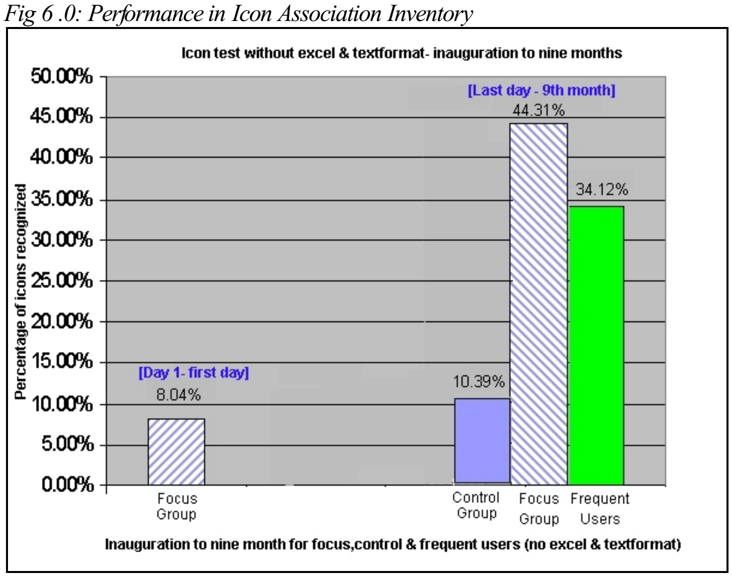


Table 7.0 First day Vs. Ninth Month Results – Focus group

	Mean	N	Std. Dev	Std. Error Mean	t	df	Sig.
First day	1.18	40	.90	.14	-7.042	39	.000
9th month	5.78	40	4.74	.75			

Table 8.0 Results in the ninth month (by group)

	Group	N	Mean	Std. dev	Std. Error mean	t	df	Sig
Focus Vs. Control	Focus	40	5.78	4.74	.75	5.479	43.881	.000
	Control	24	1.54	.93	.19			
Focus Vs. Frequent	Focus	40	5.78	4.74	.75	1.281	57.770	.205
	Frequent	40	4.70	2.40	.38			
Control vs. Frequent	Control	24	1.54	.93	.19	-7.444	55.160	.000
	Frequent	40	4.70	2.40	.38			

c) Meleykota

Fig: 7.0: Performance Icon Association Inventory

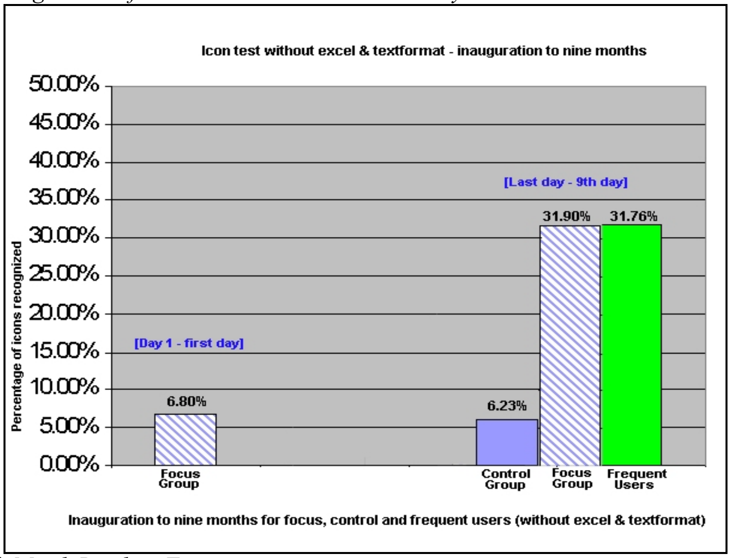


Table 9.0:First Day Vs. Ninth Month Results – Focus group

	Mean	N	Std. Dev	Std. Error Mean	t	Df	Sig.
First day	.87	60	.47	6.04E-02	-13.09	59	.000
9th month	4.07	60	1.67	.22			

Table 10.0: Results in the ninth month (by group)

	Group	N	Mean	Std. dev	Std. Error mean	t	df	Sig
Focus Vs. Control	Focus	60	4.07	1.67	.22	13.885	74.802	.000
	Control	28	.86	.45	8.47E-02			
Focus Vs. Frequent	Focus	60	4.07	1.67	.22	.054	118	.957
	Frequent	60	4.05	1.72	.22			
Control vs. Frequent	Control	28	.86	.45	8.47E-02	-13.424	73.985	.000
	Frequent	60	4.05	1.72	.22			

d) Honnalagere

Fig 8.0: Performance in Icon Association Inventory

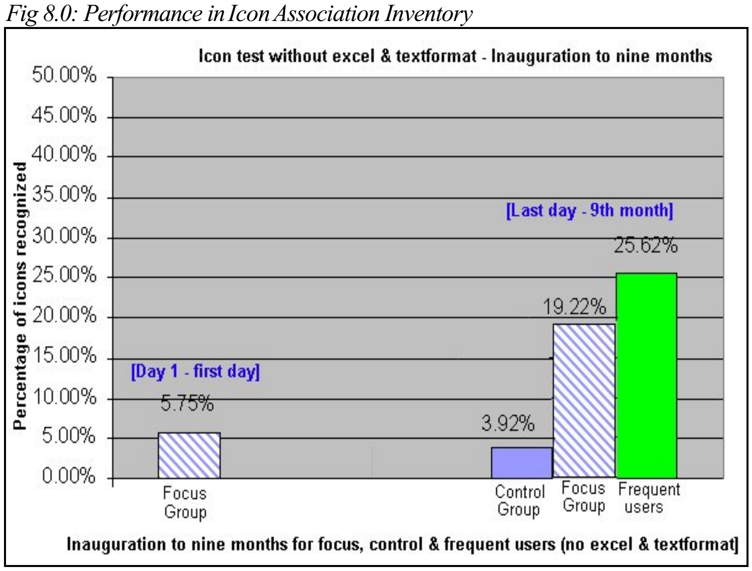


Table 11.0: First day Vs. Ninth Month Results – Focus group

	Mean	N	Std. Dev	Std. Error Mean	t	Df	Sig.
First day	.72	60	.61	7.92E-02	-8.985	59	.000
9th month	2.45	60	1.84	.24			

Table 12.0:Results in the ninth month (by group)

	Group	N	Mean	Std. dev	Std. Error mean	t	Df	Sig
Focus Vs. Control	Focus	60	2.45	1.84	.24	7.623	75.567	.000
	Control	28	.50	.51	9.62E-02			
Focus Vs. Frequent	Focus	60	2.45	1.84	.24	-2.204	118	.029
	Frequent	60	3.35	2.58	.33			
Control vs. Frequent	Control	28	.50	.51	9.62E-02	-8.231	68.244	.000
	Frequent	60	3.35	2.58	.33			

We observed that when the focus group children (MIE children) were tested on computing skills as measured by the IAI (paper and pencil version) on the 1st day and on the 9th month i.e. the last day of exposure to MIE kiosks (figures 2.0, 3.0, 4.0 & 5.0), there was a significant difference in their level of computing skills. In other words, children exposed to the MIE kiosks are able to pick up computing skills on their own without any adult intervention or formal teaching.
As mentioned earlier, the control group were children who were never exposed to the MIE kiosks. These children were also tested on computing skills in the ninth month. Results show that when their scores after nine month were compared with the scores of the focus group on the 1st day, there is no significant difference in their performance. This shows that children not having access to MIE kiosks did not acquire computing skills.

The frequent users i.e. children who visited the kiosk regularly but who were not part of the focus group were tested on computing skills in the ninth month. Similarly, the control group was also tested in the ninth month. A significant difference in the performance of frequent users and control group is observed in the ninth month. Frequent users performed significantly better than the control group. This further strengthens the argument that children having access to the MIE kiosks pick up computing skills on their own.

If we compare the acquisition of computing skills between focus group children and frequent users, we find that there is no significant difference between the two. In other words, children using the MIE kiosk, whether focus group or frequent users, picked up computing skills on their own. This further verifies our hypothesis that children having access to MIE kiosks will pick up computing skills on their own. The above findings also indicate that there is no Hawthorne effect on the focus group children in spite of the IAI being administered at periodic intervals.

If we examine the results for each village individually, we find variations in the acquisition of the computing skills among the sites. For example, in D'Salundi and Kalludevanahalli, children have acquired 44.31% and 43.27% of the icons, respectively. In Meleykota and Honnalagere, children have acquired 31.90% and 19.22% of icons, respectively. The site where children have acquired the most computing skills is D'Salundi and the site with least acquisition of computing skills is Honnalagere. The difference in acquisition of computing skills is significant across these two sites.

Interestingly, if we examine both these villages, we find that in D'Salundi, there is a very active NGO-group called the "MYGRAD," which runs awareness programs for children and women. Teachers and community members report that there has been a substantial drop in the rate of child marriage and the number of school dropouts. This could be one of the contributing factors as to why children have performed best in this village.

If we now examine Honnalagere, we find that the village is located in the Mandya district and is more or less self-contained (as compared to other villages). Hence, one of the most plausible reasons could be that there, children do not find the kiosk as interesting as children in a village where there are no basic amenities (Kalludevanahalli).

Also, interestingly, the kiosks in D'Salundi and Kalludevanahalli are placed within the school premises whereas in Meleykota and Honnalagere these are placed on the Gram Panchayat (local government) land. Can different levels of social modernization within the village and the location of the kiosk possibly cause a difference in the learning? This aspect is worth closer examination and would justify further research beyond the scope of our study.

Learning curve

The next diagram shows the learning curve of the focus group. This is drawn using the monthly test results data and, subsequently a predictor curve is fitted to it. The parameters (shown below each curve in the form of a table) explain the nature of the fitted or predictor curve. These parameters describe:

i) The carrying capacity of the curve - refers to the point up till where the child can learn computing skills on his own. After the child reaches this point, an intervention is required to enhance his/her learning.

ii) Growth rate in that particular site – refers to the rate of progress at which the children at the site are picking up computing skills.

iii) Initial knowledge of the focus group children- refers to the basic knowledge that the children have prior to using these computers.

iv) Knowledge achieved by the ninth month – refers to the level reached by the children after nine months of exposure to the computers (MIE kiosks).

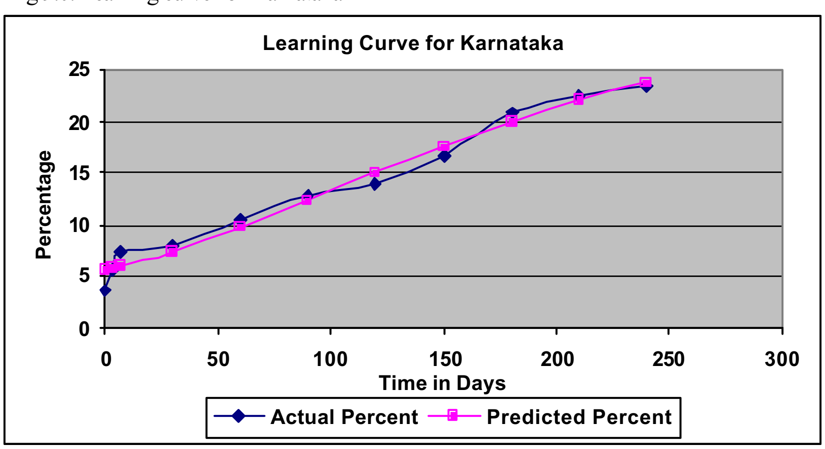
v) Any scope of further learning (by the children themselves) – refers to whether after the nine months of exposure, is there any chance for the child to still be able to learn from these kiosks.

vi) The "goodness of fit" of the model [R^2 and MSE] – refers to the appropriateness of the model.

The learning curves are shown one after the other: first the overall curve for all four sites and then the learning curve for each site individually.

Karnataka (all four sites):

Fig 9.0: Learning curve for Karnataka

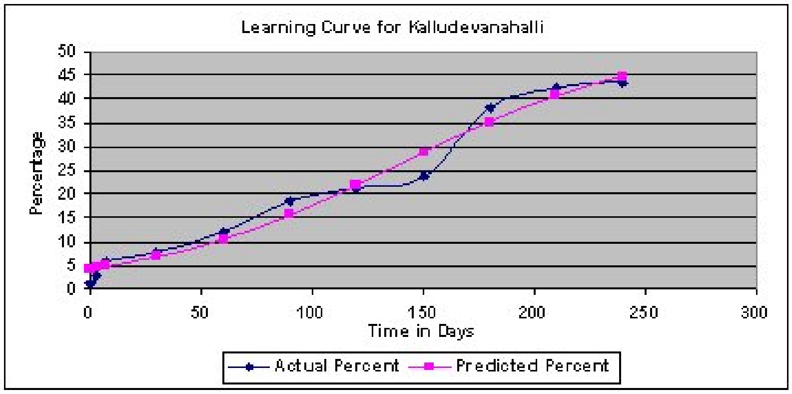


Carrying capacity	Growth rate	Initial Knowledge	Achieved	Scope of learning	R^2	MSE
35.61%	1.17%	12.33%	80.43%	19.75%	0.975	2.68

Learning curves site by site

a) Kalludevanahalli

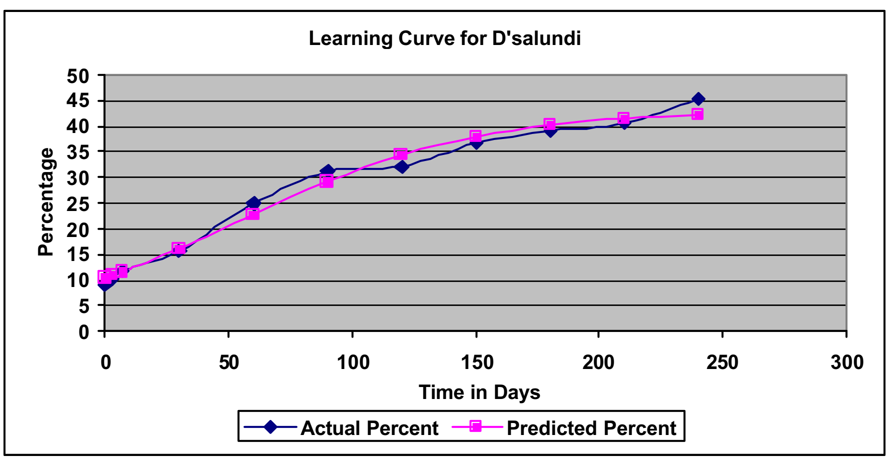
Fig 10.0: Learning curve for Kalludevanahalli



Carrying capacity	Growth rate	Initial Knowledge	Achieved	Scope of learning	R^2	MSE
52.54%	1.73%	2.49%	82.58%	17.42%	0.974	3.61

b) D'Salundi

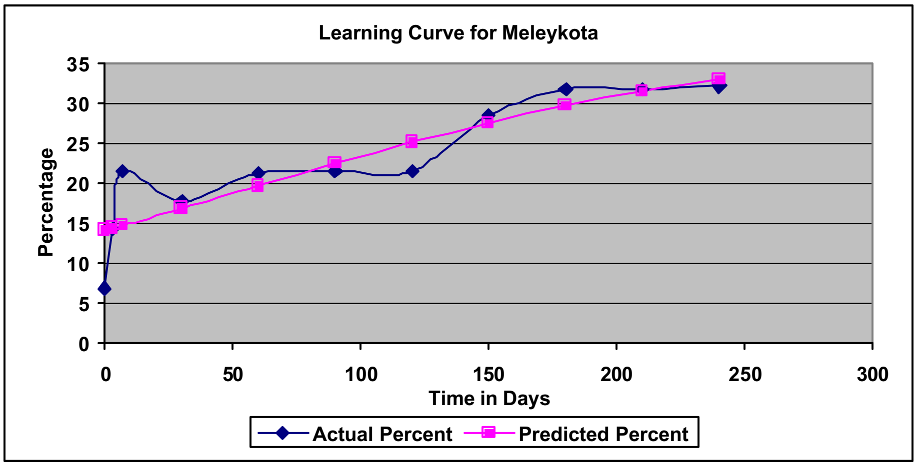
Fig 11.0: Learning curve for D'Salundi



Carrying capacity	Growth rate	Initial Knowledge	Achieved	Scope of learning	R^2	MSE
43.15%	1.86%	19.19%	100%	Nil	0.987	1.433

c) Meleykota

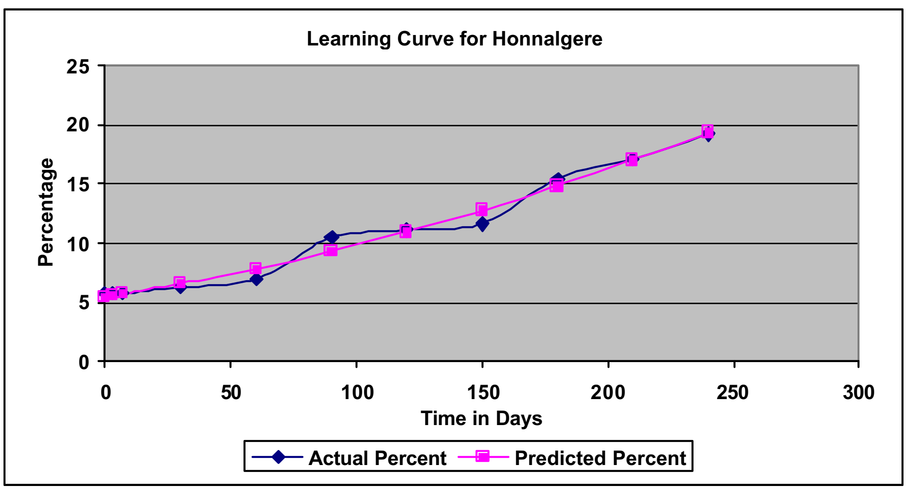
Fig 12.0: Learning curve for Meleykota



Carrying capacity	Growth rate	Initial Knowledge	Achieved	Scope of learning	R^2	MSE
33.65%	0.67%	20.56%	95.57%	4.43%	0.982	15.18

d) Honnalagere

Fig 13.0: Learning curve for Honnalagere



Carrying capacity	Growth rate	Initial Knowledge	Achieved	Scope of learning	R^2	MSE
48.72%	0.68%	11.8%	39.45%	60.55%	0.983	.517

The learning curves indicate that there is initial knowledge about computing skills at all the four sites, though negligible. This knowledge increases at a particular growth rate, which varies from site to site. This suggests that different groups are learning at different rates. Further, the learning curves are S-shaped, which means that there is a spurt of learning followed by a plateau and again a spurt of learning and a plateau. The S-shaped suggests that children learn something and then they tend to crystallize or assimilate their thoughts (the plateau stage).

At all the sites, except D'Salundi, there is further scope for self-learning by the children. This suggests that at the other three sites, children can learn more computing skills on their own. However, in D'Salundi, the focus group children have already achieved their maximum potential in the proposed self-learning model. Perhaps intervention is necessary to help these children take their learning to the next stage.

However, if we look at the overall performance of the children in the state of Karnataka, we can say that irrespective of regional differences, children have acquired computing skills on their own. The acquisition of computing skills for Karnataka as a whole is 34.01% of the icons. The children started with initial/prior knowledge of 12.33% and achieved 80.43% of their potential. In other words, there is still scope for further learning. According to the logistic model, these children can acquire up to 35.61% of the icons, after which an intervention will be required to enhance their learning. Most importantly, it is evident that learning is indeed happening in Karnataka at all site locations.

CONCLUSION

The results of this experiment indicate that groups of children can learn to use computers irrespective of who or where they are. In spite of their diversity in terms of ethnicity, language, gender and socio-economic status, they all acquired computing skills on their own.
Poor people in developing countries tend to live in dispersed geographical contexts and are comprised of diverse populations of youth and adult learners. In this context, distance education through ICTs can be an effective tool (http://www.unescobkk.org). This has been confirmed by our experiment on MIE education.

Our current and future research is focused on analyzing the complete learning environment that children at an MIE kiosk experience. This includes measuring the effect of MIE on their wider academic performance. We will report on these results in due course.
So far, the successful results showing that computer literacy can be acquired without formal instruction already call for new ways of applying this principle for children's learning, especially for those in disadvantaged communities. Foremost among these applications is primary education here; MIE can supplement the traditional education system.

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Annex I

Modelling the progress of knowledge gained over different periods of time

Progress achieved over time can be modelled by fitting various linear and non-linear statistical regression models by employing the principals of least squares. Simple linear regression uses the method of least squares to fit a continuous univariate response as a linear function of a simple predictor variable. In our case, the response variable, denoted by (y), is ICON recognition and the predictor variable, or the independent variable, denoted by (x), is the time period. In the method of least squares, we fit a line to the data so as to minimize the sum of squares due to error component, or sum of squares due to residuals. Given a set of n data points (observations) y_i of the response variable corresponding to a set of values x_i of the predictor, one can think of a functional relationship, such as:

$$y_i = f(x_i) + \text{error}$$

Or, more specifically, one may think of very simple linear regression model of the type

$$y_i = a + b\,x_i + \text{error}$$

$$y_i = a + b\,x_i + e_i$$

In this case, the residual or the error component is defined as the difference between the i-th observation y_i and the fitted value from the model.

$$\text{error} = e_i = y_i - (a + b\,x_i)$$

Thus, in all statistical models, the assumption of an error component in the model is a must because it helps in estimating the unknown parameter by using the concept of minimizing the sum of squares of residuals, or in common terms, the error sum of squares.

In linear models, minimizing error sum of squares will always lead to an explicit solution and we will always have a unique solution of the unknown parameters. In non-linear situations, however, minimizing sum of squares due to residuals may not yield a direct solution of the unknown parameters, as an explicit solution of the non-linear system of equations may not exist. In this case, iterative procedures need to be used.

For a given model, we start with some guessed values for the unknown parameters and improve this guess on repeated iterations until the final solution is stable i.e. it cannot be improved with further iteration.

In our case, when we plotted the progress of icon recognition over a period of time, we fitted models from a family of non-linear models. One such model is the LOGISTIC MODEL, which is a general model to explain the S shaped curve. In the case of the logistic model, the following equation is fitted to the data

$$y(t) = \{C/[1 + B \exp\{ -A^* t \}]\} + e$$

Where y(t) is the IAI score at time t. A, B, C are the unknown parameters and e, is the error term. Parameter A is called the "intrinsic growth rate" and parameter C represents the "carrying capacity". The term B = C/ y(0) – 1 is a function of the initial value of the observation y(0). A non-linear iterative procedure is used for fitting this model to the data. To start the iterative procedure, initial estimates of the parameters of the model are required. Many sets of the initial values are tried to ensure global convergence. The iterative procedure is stopped when the reduction between successive residual sums of squares is found to be negligibly small. After the model is fitted, two more parameters viz. P and Q can be worked out as under

P = Initial value / carrying capacity

This will help in assessing the initial aptitude or knowledge

Q = Last value/ carrying capacity

This will help in assessing what has been achieved at the end of the experimental period.

Finally, (100 – Q) will be used to assess the extent of progress that still can be achieved, in other words, the scope for further improvement.

Further, the carrying capacity C can also be used to find out the time period at which a point of inflexion may occur. This is a point at which the shape of the learning curve may change. In our case, this may be the point in time where a "minimal intervention" may be required.

The fitting of a non-linear model will help to predict performance at a given point of time. The goodness of fit of the model is an important component and can be assessed through various measures such as R^2, ROOT MEAN SQUARE ERROR (RMSE), and MEAN ABSOLUTE ERROR etc. In the present case, we have employed both R^2 and RMSE as the criterion for assessing the of the model. High values of R^2 and low values of RMSE help in identifying the appropriate model.

It is indeed, frivolous, but tempting, to point out that the final non-linear curve that we got in Karnataka is that of an electrical capacitor, charging. It is familiar to all students of electrical engineering!