Basis for the keynote speech at the Asian Science and Technology Conference in the Year 2000, Tokyo, Japan, June 6, 2000.

Basis for a talk at the Doors 6 conference of the Doors of Perception at Amsterdam, Holland, November 11, 2000

Children and the Internet: New Paradigms for Development in the 21st Century

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Abstract

Development in the 21st century will be determined, to a large extent, by the thought, action and imagination of young people. This in turn, is shaped by the education system. This paper examines the current systems of education and analyses why they are often perceived as irrelevant. A new structure of for determining what should be taught and in what order, is proposed. The paper goes on to describe the results of several experiments conducted in the area of self-instruction. Based on observations from these experiments as well as from constructivist theory, an approach named Minimally Invasive Education is proposed and the process described. The analogy and role of self-organising systems in future education is mentioned.

Introduction: Do we need a new paradigm?

Human development in the 21st century will depend on how we cope with an explosion of knowledge. We have learnt more in the last fifty years than we did in the last fifty thousand. Or so we believe.

This explosion is a consequence of networking. Humanity is networking itself rapidly into a single collective consciousness. Like a beehive, or a coral reef, or even a snowflake, the whole will be greater than the sum of its parts.

This then is the Gestalt of German psychologist Karl Jung. Made possible by a technology that he could never have imagined.

This article is about education and the shaping of this collective SuperMind.

Architects of the 21st century

The present century will be built by children born since 1980 or so. The oldest of these are in their early twenties when this article is being written (May, 2000). While these young architects of the young millennium will use the ideas and wisdom of preceding generations, much of these will not be relevant to them. It is important to realise that a lot of human experiential knowledge is no longer valid, relevant or even correct, today.

These children will need to create many new paradigms and solutions to strange new problems. Imagination, creativity and lateral thinking will become the most important agents of change.

And change is what the new century will be all about.

Schools, classrooms and life

The children who will shape the new century are being brought up in an educational environment that has remained mostly unchanged for over a thousand years.

Education is “received” in schools. Schools are generally organised into classrooms, libraries, workshops, laboratories and playing fields. Instruction is given mostly in classrooms and the outcomes evaluated through examinations.

Life in the 21st century is considerably different from that in previous times. Homes are smaller, families are more mobile than ever before. As a result, most children need to change schools two or more times.

Money and material success are considered the goals of modern living. As a result, students often perceive their school education to be irrelevant to their lives, now and in the future.

Curriculum and relevance

The most important resource in most school education is the text book. Since the medium of the text book continues to be printed matter, the cycle time for the production of new text books is in years. As a result, curricular change is a very slow process in the school system.

Slow changes in curriculum leads to further loss of relevance in a society where quick acquisition of skills is considered more important than the learning of theory. The dramatic changes taking place in biotechnology, genetics and computer science are reflected very little in the formal school system of most countries.

Teachers

The entire thinking of generations is shaped by school teachers. However, the status of a school teacher in society has declined steadily in the last 50 years. Teaching is no longer a preferred profession for anybody. Often, a person becomes a teacher only after he or she has not been able to enter any other profession.

This results in teachers who have low motivation to teach and who, additionally, often lack the ability to do so.

Even for the rare teachers who are self motivated, there exists very few means by which they can update their knowledge and skills, both in their subject areas or in their knowledge of pedagogy.

Children and society

21st century society is characterised by speed, change and material aspiration. Families are small, solitary and very mobile. Marriage, as a social contract, is fast losing its meaning and relevance. Children spend a lot of time on their own. They often grow up with single parents. The concept of permanence is very different today than it was even fifty years ago. Children expect change all the time. They are also aware of the fact that everything can change, including their parents, their home, their school and their friends. They are often solitary and non-communicative. They have few friends although many can be aggressively extroverted. Since they expect rapid change, they see very little relevance in retaining anything, including knowledge.

What do children need to learn?

According to the UNESCO, there are four “pillars” of learning:

1. Learning to know
2. Learning to do
3. Learning to live together
4. Learning to be.

It is unfortunate that learning to know and learning to do are generally perceived as different activities. It is because of this perception that many people believe that much of what they learnt in school is not relevant to their subsequent lives. This perception is further strengthened by stories of “self-made” businessmen or stories of “rags to riches”. There is a great lack of interest in theory and knowledge. This has resulted in a lack of interest in science. This is a potential threat to national and global development in the future.

Learning to live together is dependent on values. Most countries today distinguish between value education and religious instruction. However, there exist few examples of a clear statement of values other than religious texts.

Learning to be is often described as self-actualisation. It is generally believed that this can only be achieved by the learner on his or her own. In a fast changing world where role models are almost non-existent, it is very difficult for a child to either understand or practice self-actualisation. On the contrary, most children have thought very little about who they are, why they are what they are, and what they would like to be.

Skills, applications and theory

There are two dimensions to what children should learn. The first dimension is a generic one that is applicable to all subjects. The second dimension concerns the content of what they should learn.

Anything that is learnt can be described as a skill, an application or a theory. A skill is the ability to carry out a task, an application is a task that has meaning and usefulness. Theory helps the learner understand why an application works the way it does.

For example, using a brush and watercolours for painting is a skill, making a painting using this skill is an application, and knowing why and how colours can be mixed to make other colours is theory.

It is our contention that children will make attempts to learn a skill if they find the end application interesting. If they master the skill and continue to make applications, they will eventually get interested in the theory of how it all works.

In most existing systems of education, the theory is taught separately from applications and skills. Usually a theory is taught first, followed by skills (in the laboratory or workshop) and finally, some application is created or discussed. The end application is generally too far away for a child to relate the theory to it. Hence, they question the relevance of the theory.

Content

There are many ways to list what children should learn. We have classified the necessary material into four categories. These are as follows:

1. Communication, language and media
2. Science and engineering
3. Mathematics and the Arts, and
4. Values and behaviour

We think these classifications are sufficient to represent all that is taught in school.

Table 1 shows the two dimensions of children's education described above as a matrix.

	Applications	**Skills**	**Theory**
Communication, language and media	Plays, debates, stories, films, CDs, games, etc.	Written and verbal skills, multimedia computing skills, gesture, appearance, manners etc.	Grammar, linguistics, literature, poetry, film appreciation etc.
Science and engineering	•Communications •The Internet •Electronics •Computers •Power and Energy •Aerospace & Military •Medical science •Software •Test and measurement •Transportation •The environment etc,	Computing, programming, laboratory and workshop. Also reading and analysing skills. Etc.	The sciences and engineering
Mathematics and the arts	Accounting, buying and selling, graphic arts and 3D, Music, special effects, design, etc.	Arithmetic, painting, crafts, keyboarding, organising, connecting equipment, etc.	Mathematics, Fine arts, graphic arts theory, history, etc.
Values and behaviour	Self actualisation, happiness, Personality, popularity, friendship, attractiveness, etc.	Judgement, interpersonal skills, manners, dressing and appearance, behavioural skills, etc.	Cognitive sciences, religion, philosophy, metaphysics, culture, finishing school etc.

Table 1. The two dimensions of school education: The 12 education spaces defined by the matrix are filled in with sample matter only and are not complete in any sense.

Using a table of this sort, it is possible to construct a curriculum that starts from application, moves on to skills and finally to theory.

How do children learn?

There are many 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.

It is in the context of collaborative learning and constructivism that networked computing environments become important.

Children are instinctively "good" at using computers. While I could not find a study to support this, I base this impression on twenty years of experience with children using computers. Parents of children who have computers would say, almost without exception, that the child is able to do (what they, the parents) consider complex and impressive. Two explanations could exist for such reports on children using computers:

1. That children are able to self-instruct themselves to use computers for many tasks. This is impressive to adults and other children.
2. That adults are not able to do the above and, therefore, are highly impressed by children's abilities in this area.

Collaborative computing is a relatively new area, and one that is changing and developing rapidly. The effects of collaborative education in such environments are not very well understood. In what follows, I will report on a number of observational experiments in this area conducted over a ten year period. In the process, a "minimally invasive" model appears to have interesting possibilities.

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.

Lessons from constructivism

The LEDA experiments

LEDA stands for "Learning through Exploration, Discovery and Adventure". Sets of experiments were conducted in the period from 1991-1996. Each experiment was a one week summer school where groups of heterogeneous urban children in the age group 4-16 years were exposed to highly networked computing environments, provided with media and entertainment resources and allowed to formulate their own projects.

Each summer school received high quality feedback from students and parents. Results showed that children were capable of doing the following:

1. Understanding and using networked environments to exchange data, chat, use e-mail and the Internet
2. Understanding and using graphics, 3D and animation packages. This is an activity they seem to enjoy the most.
3. Discuss complex issues, such as, "Are computers alive?" with each other and come to conclusions.
4. Organise themselves for fair and efficient use of computer time.
5. Entertain each other, particularly the very young children, when bored.

6. Helping each other learn whenever required.

The Udang experiment

In 1994, a computer was installed in a village called Udang in the state of West Bengal in India. The installation was in a school and it was observed that both students and teachers were comfortable with its operation within a few weeks, with minimal instructions. In other words, they were able to teach themselves the fundamentals of computing (Zielenziger, 1995) and found enough self-motivation to do so. The students went on to create a database containing information about their village and the information was subsequently used by the government of India for decision making purposes. The Udang school continues to serve as a computer skills training centre for the local villages of the area.

The Kalkaji experiment

This experiment was conducted in 1999 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.

An outdoor kiosk was constructed such 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. 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 driving the

Photo1: Children examining the Kalkaji kiosk on the first day.

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, suitable hard disk, a true colour 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.

Our observations over a three month (Mitra, S and Rana, V., 2000) indicated that these underprivileged children, without any planned instructional intervention, achieved a certain level of computer literacy. They were able to self-instruct and to obtain help from the environment when required. In the author's opinion, this is a common phenomenon among urban children. The present experiment seems to suggest that a similar phenomenon may happen in the case of underprivileged children with little or no formal education.

We realise that the work described above is not a controlled experiment. It is a set of qualitative observations about the changes in a societal group caused by a (controlled) change in the environment, namely, the introduction of an Internet kiosk. It is in this sense that we use the word "experiment" in what follows.

Following is a list of our key observations from this experiment:

1. Once available, the kiosk was used immediately by children (about 5 to 16 years old). These children had a very limited understanding of the English alphabet and could not speak the language.

2. Children learnt basic operations of the PC for browsing and drawing within a few days.
3. Adults, both men and women did not make any attempt to learn or use the kiosk.
4. MS paint and Internet explorer were the most commonly used applications
5. Children formed impromptu classes to teach one another,
6. 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.
7. Within a month of interaction, children were able to discover and use features such as new folder creation, cutting and pasting, shortcuts, moving/resizing windows and using MS Word to create short messages even without a keyboard.
8. Children were strongly opposed to the idea of removing the kiosk
9. Parents felt that while they could not learn the operation of the kiosk or did not see its need, they felt that it was very good for the children.

The Kalkaji kiosk continues to be operational (February, 2000) and about eighty children use it. We were able to evolve an engineering design for a kiosk that would operate with negligible maintenance and without air conditioning in tropical environments. Their usage varies from activities around painting and music, to browsing and attempting to build a web site.

The Shivpuri experiment

An Internet kiosk identical to the one described above was constructed in the town of Shivpuri, state of Madhya Pradesh, in central India. Shivpuri is a rural town with very little computer usage in any segment of society. The kiosk was made operational for three months (May to July, 1999) with a dial-up Internet connection. Our observations were nearly identical to those obtained in the first experiment and are reported elsewhere (Mitra, S., 2000).

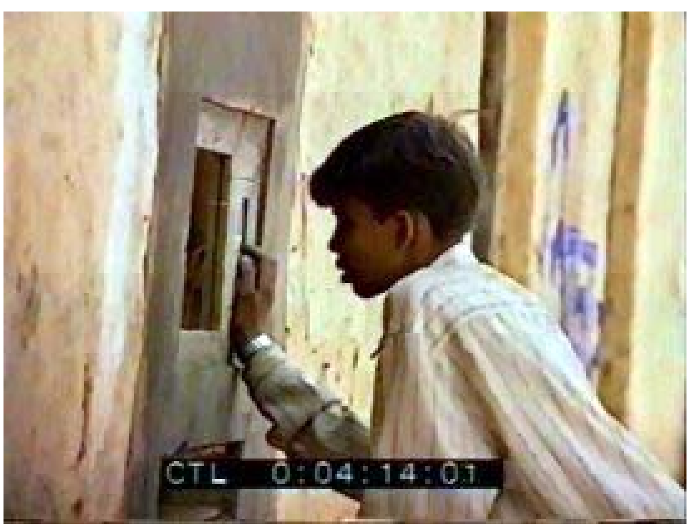

Photo 2: The Shivpuri kiosk

The Madantusi experiment

The experiment was briefly repeated in a third location, in the village of Madantusi, in the district called Harchandpur, about 60 kilometres from the city of Lucknow in northern India. This was a purely rural location with one small school containing about 70 children. There are no computers in the village and no one had seen one. I installed a notebook PC (working on batteries and without an Internet connection) running the Windows '98 operating system, in a classroom and left it there for an hour. The children were found looking at digital images of various places in the world, and playing music files, at the end of the period. We hope to repeat the experiment later in a more controlled manner.

Photo 3: The Madantusi experiment

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.

MIE Technology

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 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.

MIE economics

We evaluated the cost of education in these experiments. The cost of setting up an outdoor Internet kiosks in India is around USD 5000 including the cost of a leased Internet line (64 Kbps). The running cost of the kiosk would be approximately USD 5000 for a year.

In the experiments reported above, about 100 children benefit from each kiosk. Hence, the cost of MIE per child is USD 100 per annum. This is about three times less than the cost of conventional computer education for similar learning objectives, in India, at this time.

How far can it go?

Like most educational models, a single solution cannot be proposed for all problems. While the MIE model can serve as a tool for learning, it would need to be integrated with other models of education to produce the correct solution for each learning situation.

Collaboration and remote presence on the Internet

No discussion on Internet based education can be meaningful without a discussion about the future technologies that may impact learning. At this moment (May, 2000) the technologies of collaboration, remote presence, mobile computing and Internet appliances would appear to be in the immediate horizon.

Collaborative environments on the Internet

Collaboration between individuals on the Internet can be done in many ways. These are:

1. Web pages and sites
2. e-Mail
3. Bulletin boards
4. Chat sites and Internet Relay Chat (IRC) servers
5. Voice over IP (VOIP)
6. Newsgroups
7. Video telephony over IP and remote presence
8. Mobile Internet access using the Wireless Applications Protocol (WAP)

Of these, the first six technologies are already available, while the last two are in the process of being tested for deployment. All of these technologies can, and should, be used for education.

Remote presence technologies

Remote presence technologies rely predominantly on accessing and controlling artificial sensory systems over the Internet. For example, the ability to operate a web camera over the Internet is equivalent to transporting one's eyes to a virtual location.

In the NIIT R&D labs in New Delhi, we have been experimenting for some time with vehicles fitted with moveable cameras and microphones that can be driven from any Internet client connection. This is equivalent to virtual travelling in real space in near real time. These experiments are similar to space missions, particularly the Mars pathfinder mission from NASA. However, the technology is immensely cheaper and therefore conceivable for consumer use.

WAP and Internet appliances

Mobile access to the Internet is the latest consumer craze, particularly in Japan. Using WAP phones to access the Internet, instead of PCs, is likely to become the preferred mode of access by 2005. WAP telephony is, therefore, likely to give rise to the easiest form of kiosk applications for MIE. It is important for companies and governments to start investments in this area from right now.

It is not clear whether the WAP phone will remain the dominant device for the consumer for very long. It is equally possible that a palm sized PDA (personal digital assistant) may replace the mobile phone as the preferred device for communication. Such devices are called Internet appliances and are likely to be vital for lifelong learning situations.

Things that learn, Things that teach

Wireless devices that are connected to and controllable from the Internet are visible in the near future. Such devices may or may not have their own processors. The concept of ASP (Application Service Provider) involves devices that appear to compute, while they are actually using the computing resources of a service provider through a wireless connection to the Internet.

Such devices hold immense potential for instruction. Toys with variable behaviour, books with changeable contents are examples of "things that learn and then teach".

These then would be the eyes, ears and mouths of a seamless, borderless, wireless world.

Conclusion

Self-organising systems and the future of education

Self-organisation refers to spontaneous ordering tendencies sometimes observed in certain classes of complex systems, both artificial and natural (Depew and Weber, 1999). *Such systems have a large number of components that interact simultaneously in a sufficiently rich number of parallel ways, are at best only partially decomposable, are sensitive to initial conditions when they are in the chaotic regimen, are constrained away from their most probable state, and exhibit non-deterministic bifurcations in their dynamic trajectories.*

This rather complex definition is at the cutting edge of computer science today. It is an exciting subject, one that might, one day, reveal to us the secrets of life and consciousness. In the context of this paper, I find that there appears to be great similarities between the processes of self-organising systems as defined above and collaborative or minimally invasive approaches to learning.

It was necessary to learn facts and figures because it was not possible to carry all the books in the world, or access the information in them, even if one could. In a massively connected world, it is possible to have such resources on devices that fit into a shirt pocket. Content and access, therefore, will not be major issues in education in the near future. The process of learning will convert itself into a process that enables us to organise vast amounts of knowledge in our machines and our minds. A teacher can only help in such organisation, in the role of an assistant. Often that too will not be required as machines take over the task. Learners will collaborate independently over space and time to accelerate the process of organisation of knowledge.

Letting it happen

Self organising systems have low predictability, they are "grown" and not "made". In a sense, they represent our transition from the industrial to the information age. "Making it happen" was the management paradigm of the age gone by. "Letting it happen" will be the strategy for building the systems of the new age.

The real paradigm shift in education will be the conversion of the educational process into self-organising systems.

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