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international prize in education

2019 Brock International
Prize in Education Nominee

Sugata Mitra

Nominated by Jeff McClellan

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Letter of Recommendation

I have committed my life to improving the educational experiences of underrepresented student populations. I have worked to transform an existing comprehensive high school environment; I have led an innovative start-up STEM High School; and I have worked on large scale projects nationally and internationally. I have seen what can be achieved when all the right conditions are in place. I have also seen how hard it is to replicate these successes at scale. What I have found is that most innovative practices do not scale successfully because the innovation requires so much time, money, or commitment on the part of the adults involved that adequate evidence of success cannot be reached fast enough for the innovations to have the chance to stick.

Dr. Sugata Mitra introduced the Self-Organized Learning Environment (SOLE) in his award-winning Ted Talk in 2013. While looking at what groups of children can "teach themselves" when they have access to the internet and support from a caring adult, Sugata has introduced a new pedagogical tool into the world that addresses many of the inherent challenges in classrooms today while remaining simple to implement and cost efficient.

SOLE pedagogy is modeled as a catalytic innovation that sanctions the student to explore multiple new dimensions of autonomy while quickly sharing connectivity with a group of peers. It strengthens collaborative competency by the nature of the task. Drawing on the need for interaction, it is a communication shaped by conversation and negotiation, which emerges through inquiry, data collection, shared experience and reflection. The rapid collaboration required to accomplish these goals allows students to develop clarity, accuracy and precision, as well as the ability to integrate sound evidence, with an appreciation for equity in the process. Critical thinking is mandatory for reaching mastery in the methodology. SOLE provides a space where learning evolves from an important set of 21st century learning skills. Students must conceptualize a process for information collection, apply newly learned skills, analyze their progression within the group, blend it with existing knowledge, synthesize relevant information, and finally prioritize that information in order to present it to others. Technology has opened the door with access to the knowledge economy, and it must be integrated into learning today, as it provides the gateway to exploration outside the traditional academic sequence.

Over the last four years I have led a startup team of educators, researchers, and developers focused on scaling student-centered inquiry. Inspired by Dr. Sugata Mitra's concept of SOLE, we at STARTSOLE have developed a series of tools and techniques that supports the systematic implementation in classrooms everywhere. In general, student-centered, inquiry-based approaches require extensive preparation and special teaching modules which are cumbersome to insert into a busy class schedule. In contrast to this, SOLEs can be completed in a single class period by one teacher using a question aligned to state standards. These SOLE sessions easily fit into any educational environment and when used regularly (one period a week or every other week) allow the educational environment to quickly change.

My STARTSOLE team launched a series of tools designed to allow educators to seamlessly incorporate SOLEs into their natural classroom environment without any special preparation or extensive training of the educator. STARTSOLE was designed to facilitate an educator's ability to seamlessly apply inquiry learning with as little pre-training or cost to the educator or school as possible. From 2014 until now, we have established an installed base of over 10,000 educators (predominantly K-12) living in 90 countries. These educators work in over 2,500 schools, and the STARTSOLE experience has reached an estimated 400,000 K-12 students. As part of the pilot launch of STARTSOLE, a data collection system was integrated into the delivery and use of the mobile application. STARTSOLE has the potential to bring student-centered inquiry learning into every classroom and into the hands of every educator.

My example is only one story of how Sugata Mitra has inspired many. The simultaneous simplicity and complexity of SOLE itself, driven by Mitra's vision, is what is opening doors for learning and exploration for children, educators, and others around the world. I credit Professor Mitra for his commitment to exploring, sharing, and championing this meaningful approach to education that I believe will continue to define and change the way we think about learning into the future.

Sincerely,

Jeffrey D. McClellan, Ed.D.
Intro to StartSOLE
Schools that Work-MC2 STEM
TEDx The Student Success Triangle

Impact Statement

The Concept

In 1999, Sugata Mitra's pioneering "Hole in the Wall" experiments helped bring the potential of self-organized learning to the public's attention. Research since then has continued to support his conclusion that groups of children, with access to the Internet, can learn almost anything by themselves. From the slums of India and villages of Cambodia, to schools in Chile, Argentina, Uruguay, the USA and United Kingdom, Professor Mitra's experimental results offer an intriguing new future for learning: a future in which 'knowing' may be obsolete, but learning is ubiquitous.

SOLE's simple yet elegant pedagogy contributes to its immense capacity for integration and disruption. Still as simple as the original experiment, a self-organized learning environment can exist anywhere there is a computer, Internet connection, and students who are ready to learn. Within a SOLE, students are given the freedom to learn collaboratively using the internet. The SOLE process is simple and easy to adopt: an educator poses a "Big Question" and students form small groups to find an answer. During a SOLE session, students are free to move around, change groups and share information at any time. Towards the end of a session they have the opportunity to share what they learned with the whole group. SOLE sessions are characterized by discovery, sharing, spontaneity and limited teacher intervention.

One of the key facets of the SOLE pedagogy is that it allows for a connection to the heart of the education system within a short period of time, without needing to disrupt the existing educational structures. It encourages change to occur in the student, in the teacher and in the school, all in one swift motion. The learner becomes the teacher and the explorer, the teacher becomes the advocate, the editor and the guide as well as a learner himself, and the system promotes a set of values that are consistent with what the 21st-century workforce seeks from our students. This change begins at the student level and ripples organically throughout the various levels of the school's ecosystem. Critically, this change then becomes embedded in the context via the stakeholders, and as a result builds a sustainable fortress around the idea of student driven learning and ownership of that learning. The result is a learning environment that has been internally redesigned and operationalized with no cost and great benefit.

Professor Mitra's SOLE concept has inspired educators around the world. The program's simple concept has made integration easy, and its intriguing results have made its spread organic. One specific example of this is STARTSOLE. Inspired by Mitra's SOLE concept, STARTSOLE has established an installed base of over 10,000 educators (predominantly K-12) living in 90 countries. The STARTSOLE app equips educators to conduct SOLEs in their classrooms, create and share SOLE questions, and log SOLE results. These educators represent over 2,400 schools, and the STARTSOLE experience has reached an estimated 400,000 K-12 students. Through STARTSOLE, SOLE has been used widely in Cleveland, OH and in classrooms and other learning spaces around the world, including a 1000-student SOLE event hosted at Cuyahoga County Community College in March 2016. Oregon City Schools has used SOLE to advance their teacher training. Downington Area School District in Pennsylvania has effectively integrated regular SOLEs into much of their classrooms. One teacher in Texas saw SOLE as a way to maximize effective lesson planning during her limited time. In Syria, a young engineering student facilitated SOLEs with students and adults alike, focusing on questions regarding basic inquiry and reliable internet research, respectively. For these users, SOLE provided not only the learning experience, but also the practice with technology and computer-based research.

Professor Mitra's introduction of the SOLE concept has led to diverse research and application of the SOLE process, incredibly in ways not much different from the SOLE concept itself: through the STARTSOLE platform, educators can actively create, test, and share new SOLE questions, perpetuating the practice of exploratory and inquiry-based learning. Moreover, exploratory research by the STARTSOLE team has begun to build out a knowledge base around SOLE. Findings have included the discovery that regular SOLEs result in: deep and broad levels of student engagement, increases in student academic, social and self-management skills, diffusion of skill sets beyond SOLE sessions, shifts in teaching role from content expert to learning facilitator, new openness among teachers to other student-centered pedagogies, and rhe spread of SOLE through informal discussions.

For students, SOLE provides a means to envision a path for and decide the speed of learning, determining their level of contribution and ownership over the direction the path takes. For teachers, SOLE provides an environment to become learners, leaders, and shared managers as students migrate that path. The new norm is an expectation that all learners can be their own innovators and navigators, and in collaboration with their peers and teachers, share the responsibility of learning and execute the right of learning with equity. The result is the creation of a new "citizen integrated engaged learner", driven by the ecology of the school and the complexity of the task, yet accomplished with a simplicity that translates into a positive learning journey. The progression of SOLE pedagogy brings the ideals of 21st century learning within reach, acknowledging a new role for teachers, while allowing them to maintain the independence of the classroom, guiding their students through this transformative pedagogy, and utilizing the benefits of technology, collaboration and adaptability.

The School in the Cloud

The School in the Cloud Lab is yet another demonstration of Professor Mitra's innovative and bold efforts towards advancing learning for children all over the world. Upon receiving the first ever $1m TED Prize award at the 2013 TED conference, Mitra asked the global TED community to make his dream a reality by helping him build the ultimate "School in the Cloud" where children, no matter how rich or poor, could engage and connect with information and mentoring online. In December 2013, the first School in the Cloud lab opened its doors to students inside a high school in Killingworth, England. Since then, seven more labs have been opened as part of Mitra's wish: five in India, one more in the UK and one in New York, USA. The labs aim to provide an environment where a global community of educators can observe the impact of self-organized learning on children from a wide range of educational backgrounds. The School in the Cloud website recognizes global SOLE organizations in 13 different countries. The School in the Cloud platform, originally launched at the 2014 TED conference, is also helping to accelerate SOLE research by helping educators—be they teachers, parents or community leaders—to run their own SOLEs and to contribute to the global experiment by sharing their experiences with others. It is now managed by SOLE Central at Newcastle University, a global hub for SOLE research and practice directed by Mitra.

Professor Mitra is also credited with more that 25 inventions in the area of cognitive science and educational technology. He was conferred the prestigious Dewang Mehta Award for Innovation in Information Technology in the year 2005. His interest in the human mind once led him into the areas of learning and memory and he was among the first in the world to show that simulated neural networks can help decipher the mechanisms of Alzheimer's disease. He was also among the first to invent Voluntary Perception Recording (a continuously variable voting machine) and a hyperlinked computing environment, several years ahead of the Internet. Professor Mitra created NIIT's first curricula and pedagogy, followed by years of research on learning styles and devices, multimedia, and new methods of learning.

Biographical Information

Sugata Mitra, PhD

Sugata Mitra is Professor and Principal Research Investigator at the School of Education, Communication and Language Sciences at Newcastle University, UK. He received his PhD in Solid State Physics from the Indian Institute of Technology in 1978. He also holds MS and BS degrees in Physics from IIT and Jadavpur University, respectively.

He conducted his paramount research study, the Hole in the Wall (HIW) experiment, in 1999: a computer was embedded within a wall in an Indian slum at Kalkaji, Delhi and children were allowed to freely use it. The experiment aimed at proving that kids could be taught computers very easily without any formal training. Sugata termed this as Minimally Invasive Education (MIE). The experiment has since been repeated at many places. He is the recipient of many awards from India, the UK, USA and many other countries in the world. His interests include Children's Education, Remote Presence, Self-organizing systems, Cognitive Systems, Physics and Consciousness.

Sugata is credited with more that 25 inventions in the area of cognitive science and educational technology. He was conferred the prestigious Dewang Mehta Award from the Government of India for Innovation in Information Technology in the year 2003. In 2013, he was awarded the first $1 million TED prize, to put his educational ideas together to create seven laboratories called 'Schools in the Cloud'. Here he is studying learning as emergent phenomena in an educational self organizing system. Professor Mitra's work at NIIT created the first curricula and pedagogy for that organization, followed by years of research on learning styles, learning devices, several of them now patented, multimedia and new methods of learning.

Starting with molecular orbital computation in the 1970s, Mitra discovered that the structure of organic molecules determine their function more than the constituent atoms. After a earning his Ph.D. in Solid State Physics from IIT, Delhi, he went on to research energy storage systems, first at the Centre for Energy Studies in the IIT and then at the Technische Universität, Vienna, Austria. This resulted in a new design for Zinc-Chlorine batteries. His interests in the flow of electricity through biological systems, a consequence of his Ph.D. research on exciton dissociation in organic semiconductors, led on to a seminally speculative paper on why the human sense organs are located where they are.

His interest in computer networking led him towards the emerging systems in printing in the 1980s. He set up India's first local area network-based newspaper publishing system in 1984 and went on to predict the desktop publishing industry. This in turn led to the invention of LAN based database publishing and he created the "Yellow Pages" industry in India and Bangladesh. He was among the first in the world to show that simulated neural networks can help decipher the mechanisms of Alzheimer's disease. He was also among the first people in the world to invent Voluntary Perception Recording (a continuously variable voting machine) and a hyperlinked computing environment, several years ahead of the Internet.

The Hole in the Wall experiment has also left a mark on popular culture. Indian diplomat Vikas Swarup read about Mitra's experiment and was inspired to write his debut novel that went on to become the Oscar winning movie of 2009: *Slumdog Millionaire*.

The Future of Schooling: Children and Learning at the Edge of Chaos

Sugata Mitra (2014)

Abstract This paper describes the effect that assistive technologies, such as paper, printing, protractors, logarithm tables, computers, and the Internet, have on pedagogy. It reports the results of experiments with self-organising systems in primary education and develops the concept of a self-organised learning environment (SOLE). It then describes how SOLEs operate, and their possible effects on primary education in remote areas, and discusses the implications of the physics of complex systems and their possible connection with self- organised learning amongst children. Finally, it proposes a change in the examination system that would incorporate the Internet and concepts of self-organisation into schooling.

Keywords Complex systems, Curriculum, Internet , Learning , Primary education, Self-organised learning environment

In this article I suggest a new approach to primary education, based on available technology and our current understanding of complexity. In order to do this, I first look at where and how the current primary education model evolved, and then at the technology available today and its effects on children. From this, I attempt to build a new model for primary education.

History and Education

Throughout the ages, the introduction of new technology has profoundly affected primary education. The introduction of reading and writing changed the emphasis of primary education from listening and reciting to good spelling, handwriting, and reading comprehension. The introduction of the decimal system brought numeracy to the very young. As more technology emerged, around the early 19th century, the real-world technology that was used for solving technical problems—such as rulers, compasses, dividers, protractors, paper, pens, and later, logarithm tables and slide rules—was also introduced into the examination hall. In other words, the learner was expected to prove that he or she was capable of solving real-world problems the way they are solved in the real world. The teachers, in order to cope with this system of examination, would encourage learners to use all of these technologies. The curriculum, too, would integrate these technologies and include them in the skills that children needed to learn. During the Industrial Revolution, knitting, sewing, kitchen automation, and a host of new technologies entered the primary school. Changing technology and examinations changes schooling (Taylor 2007).

It is important to notice that the introduction of new technology changes teaching strategies. As writing supplanted the oral tradition in schools, teachers would emphasise ‘‘taking notes properly’’ as an important skill, rather than memorising. Later, the introduction of logarithm tables into the classroom and examinations would change a teacher's emphasis from multiplying by hand and memorising tables to correctly and quickly using log tables. During the 18th and 19th centuries, curriculum remained largely unchanged throughout the world. At this time the world was mostly divided into empires. Older civilisations and empires that did not have firearms were quickly colonised by the Western empires. In order to administer a colonised world, the empires invented modern systems of administration and management, essentially systems of data processing, using people as the computing elements. Data was processed by clerks and transmitted physically on paper, using ships as the main form of transportation. Communication was through a chain of command, invented earlier by the military.

In order to produce the large number of clerks needed to administer empires, primary schooling had to adopt a factory model, aimed at producing identical and interchangeable clerks. The skills most needed by clerks and other officials in the chain of command were reading, writing, and arithmetic. These became the three pillars of primary education and they continue to be, centuries after the empires have ended.

The military-industrial-administrative machines of the Age of Empires also needed strict rules of dress, behaviour and conduct. These were introduced into primary education through religion and martial discipline. Learners were taught not to ask questions, but to obey orders and norms laid out by the society they lived in. This also continues today.

In most countries, a few schools had a more liberal education policy, with an emphasis on philosophy, history, science, the arts, and literature. These schools were designed to produce the people who would be at the top of the chains of command: those who would actually own and enjoy the lands they ruled over.

In the meantime, technologies and new discoveries from the older civilisations and empires—such as gunpowder and tea from China, opium and mathematics from India, architecture from Greece and the Middle East, tobacco, potatoes, and chillies from the New World—all went into the creation of an industrial and technological revolution in Europe. Schools became the producers of not only clerks but also accountants and factory workers. New inventions in science and engineering became more frequent but mostly benefited those who had studied in elite schools and universities. During the Age of Empires, societies slipped into the same errors committed by the empires of earlier centuries: rule by the elite and the division between the working classes and their masters.

During that era, the average school rarely needed to change its curriculum, perhaps once in fifty years, and the process of changing curriculum, examination systems, and teaching methods was geared to that pace of change. The process remains slow today.

Just as guns changed an age, two inventions were to change the age of empires: the telephone and the digital computer. By the mid-20th century, computers had begun to replace the clerks at the lowest layers of the military-industrial-administrative machine, while the telephone was shortening chains of command.

Schools struggled to cope with these changes. Computer-assisted education, computer- aided learning, programmed instruction, and computer-based teaching were all attempts to replace teachers with machines that would, people hoped, close the gap between the elite and the common people. These attempts were doomed to fail because they assumed that learning required a teacher, a classroom of 36 square metres, 30 children, and classes lasting about an hour: a model inherited from the oral tradition of 5,000 years ago.

Curricula around the world remained static: they assumed a top-down, hierarchical, predictable and controllable world that progresses slowly. There was still no reason to believe otherwise.

Three quiet revolutions in science, all around the early or middle 20th century, were revealing something vastly different about the way things work: information and disorder are related (Shannon 1948); the act of observation changes the observable (Heisenberg 1927); and connected things show emergent properties not expected from them (Huxley and Huxley 1947, p. 20).

The world of physics changed in the 20th century, from a model that was ordered, well understood and controllable, to one that was chaotic and probabilistic. We are still struggling to understand a universe that is governed by probability, chaos and emergence. Schools and the working classes they continue to produce know little of this. Others—the clerks and their managers—are in denial. They still hide in a mythical orderly world, where things happen by design.

Towards the end of the 20th century, computers began to connect to each other over telephone lines. By the year 2000, millions of them were connected; by 2010, it was billions. Connected by wireless, electromagnetic signals, the biggest network of information-exchanging entities, the Internet, was passing more bits of information back and forth than there are stars in the universe. From that cloud of chaotic interconnection order has to emerge.

Children and the Internet
When children access the Internet on large, publicly visible screens in safe and public surroundings, the net can benefit them in many ways. Groups of children can learn almost anything by themselves, using the Internet. The SOLE website (2014) provides examples of this phenomenon from all over the world.

Since 1999, a number of experiments have been building up to a pedagogical method that is considerably different from the traditional methods used in schools in the last century.

Fig. 1 Children using a hole-in-the-wall computer, 2003

In one of the first of these experiments, often referred to as the ''Hole in the Wall'', computers, connected to the Internet, were embedded into walls in villages and urban slums in India. They were much like the automatic teller machines used by banks, but their screens were larger and placed at a height that made it convenient for children aged 8 to 13 to use them. These computers had no specific learning software and children were given no instructions about what they were and what they were for, except for a sign that said they were for free use by children (Figure 1). In 1999, poor children in India often did not know what a computer was and were quite unaware of the Internet. In a study that lasted over 5 years, my colleagues and I (Mitra et al. 2005) found that children could learn how to use the computers to play games, download media, and search for information, among other things. Moreover, we placed the computers in locations where local adults knew nothing about how to use them, only that they were computers, and we designed these installations so they were nearly impossible for adults to use. Using a random sample of children in 17 locations all over India and various tests, we concluded that the children had learned to use the computers by themselves. Today, of course, this is not at all surprising.

These ‘‘hole in the wall’’ computers remained in working condition for only about two years after the experimental period, as no funding was available to maintain them after that. But during this period, my colleagues and I conducted a number of experiments and found that children, working in groups, demonstrated education achievements in these unsupervised environments. I describe these achievements briefly in what follows; to describe all of them would be beyond the scope of this paper.

It is important to note that, to reach these educational objectives, the children invariably worked in groups, interacting constantly with each other, in a somewhat chaotic way. Their approach scarcely resembled the orderly learning environment provided by a school classroom. Our observations led us to suspect that their learning was the outcome of a self- organising system. I use this term here in the same sense that it is used in the physical sciences or mathematics: a self-organising system is a set of interconnected parts, each unpredictable, producing spontaneous order in an apparently chaotic situation. I offer a more rigorous definition later in this article.

To summarise the results from these experiments carried out between 1999 and 2005, we observed four things about groups of children (usually aged 8–13), given access to the Internet and left unsupervised.

Fig. 2 A classroom using a Granny Cloud

They can learn to use computers and the Internet by themselves, irrespective of who or where they are and what language they speak (DeBoer 2009; Mitra et al. 2005).
They can achieve educational objectives by themselves, as several studies showed. They could

complete standard school examinations in computer science and mathematics (Inamdar and Kulkarni 2007); improve their English pronunciation by themselves (Mitra, Tooley, Inamdar, and Dixon 2003); and improve their school achievement (Dangwal, Sharma, and Hazarika 2014; Dangwal and Thounaojam 2011).

They showed self-organising behaviour that resulted in learning in ‘‘minimally invasive’’ environments (Dangwal and Kapur 2008, 2009a, b).
They understood content that was years ahead of that expected for their age group (Inamdar 2004; Mitra 2012).

We also found evidence (Mitra, Dangwal, and Thadani 2008) that children in remote areas perform less well in school, usually because of the quality of instruction they receive, as good teachers tend to migrate away from remote areas. An alternative method, suggested by the four points above, might help reduce this problem of performance.

In an experiment to seek the limits to such self-organised learning, we (Mitra and Dangwal 2010) found that groups of Tamil-speaking children in a southern Indian village were able to understand the basic concepts of biotechnology on their own, in English. This rather astounding result seemed to indicate that, working in groups, children were able to reach levels of learning years ahead of standard expectations. However, they understood considerably less than did a control group who were taught the same subject. We then introduced an affectionate and admiring, but not knowledgeable, adult, and found that she was able to equalise the levels of learning between the control and experimental groups. I described this friendly, non-threatening adult presence as part of the ‘‘grandmother’s method’’: stand behind, admire, act fascinated and praise. Further, in another study (Mitra 2010), I studied ways to organise retired teachers (sometimes referred to as the Granny Cloud or as eMediators) to connect with children remotely, using peer-to-peer video communication such as Skype (Figure 2).


Fig. 3 Children working in a SOLE session

Combining all these results, we can clearly see a case for creating unsupervised environments for children, as an alternative learning method. We call these self-organised learning environments (SOLEs).

A SOLE inside a school or any indoor environment simulates the environment of the outdoor ‘‘hole in the wall’’ design. We create this by keeping computers with group seating arrangements such that a group of up to 5 children can easily share each computer (Figure 3). We make sure that the number of children in the space is 4 or 5 times that of the number of computers. For each session, the children form their own groups around each computer. They are not told to do so, but they must, given the shortage of computers. Children are allowed to change groups, talk to one another, talk to other groups, and walk around looking at others’ work. There are very few rules. The teacher’s role is minimal: observe the children and stay out of their way. When all of this goes as planned, the result is the mildly chaotic situation of the ‘‘hole in the wall’’ experiment.

Teachers worldwide report on the SOLE (2014) website that they invariably observe children spontaneously creating order.

SOLEs can be used in several different contexts. During a SOLE session in a classroom, children can use computers in at least five ways:

Timetabled usage: Each class should have at least one session of about 90 minutes in the SOLE, as part of the timetable every week. During this time, a teacher will engage the children with a question that they can answer using the SOLE. Examples of questions could be: ‘‘Who built the pyramids and why?’’, ‘‘What are fractals?’’, ‘‘What are they looking for with the Large Hadron Collider at CERN, in Geneva?’’, ‘‘Who is Gandhi and what did he do?’’, ‘‘Where is Botswana and what is it famous for?’’, etc. About 30 minutes before the end of the session, the groups should produce a one-page report where they describe what they have found. The teacher can then expand on this in a later class.

Curricular usage: This is similar to the use above, except that the driving question is one taken from the school-leaving examination (for example, CBSE in India or GCSE/ SAT in the United Kingdom).

Aspirational usage: In these sessions, children listen to a short lecture from an interesting website on the Internet, such as the TED talks (www.ted.com). They then research the talk and the speaker, in groups, and present their findings.

Free usage: The SOLE should be open for any child in the school to use before and after regular school hours. It should be made clear to the children that they can use this time to play games, chat, or do whatever they wish. As usual, working in groups is to be strongly encouraged. All screens in a SOLE need to be large and clearly visible to all children and passing adults. SOLEs should, preferably, be conducted in enclosures with transparent walls.

Remotely mediated sessions: During certain times, the SOLEs can be used for connecting to eMediators. When children do it as intended, this kind of work can have a strong and positive impact on cultural development and English fluency. This approach is particularly useful in areas where teachers cannot or will not go.

Self-organised learning activity, like the types I have discussed here, is not yet clearly understood. Reading comprehension is obviously very important to the process. Moreover, when children search the Internet for information, most of what they encounter was written with adults in mind. This means that, if they are to apply effective search and analysis skills, children need to be able to read at adult comprehension levels.

At first, this would appear to be a showstopper. However, actual experience with SOLEs, as reported by teachers around the world (SOLE 2014), shows that children seem to be able to make sense of material at reading levels considerably above their own. This anomalous result is intriguing and may well be the key to understanding this form of learning.

We decided to investigate this phenomenon. To do so, we presented children with passages that are suitable for adults and tested their understanding when they read in groups, compared to when they read alone. Our results, as yet unpublished, suggest that children can read and understand adult-level text in groups if they are allowed to work in the SOLE style. In order for such higher- order reading to happen, the children should be able to read at a basic level. We do not yet know what average reading level a group requires to be able to amplify their combined level in this way. Nor do we know whether they can reach this basic literacy level by themselves.

We have observed that the SOLE method does not operate well with what one might think of as easy questions or easy-to-read materials. By ‘‘easy’’, we mean questions or material currently considered suitable for the age levels of the learner group. Children working in groups engage more deeply when confronted with questions and material well above their expected competency level. They seem to enjoy doing such tasks. We conjecture that children who perceive a task as one they are confident about doing individually would rather work alone in order to get individual credit. On the other hand, if they perceive a task as difficult or impossible, they would rather work in groups, possibly to increase their chances of succeeding and to reduce any potential discredit for getting things wrong. This conjecture needs to be tested under controlled conditions.

Schools in the Cloud

The work I have described above was carried out from 2007 to 2013 in schools around the world in collaboration with school principals who were interested in understanding how SOLEs work. However, these are traditional schools and the work was done as a one-off demonstration of a possible new method of learning. The schools involved were located in

Argentina, Australia, Chile, China, England, India, Italy, the United States, Uruguay, and several other countries. Many teachers retained their regular methods, many modified the SOLEs to suit their curricular purposes, and many did not continue with the new approach. It became increasingly important to verify the results reported above under more controlled conditions.

In February 2013, with financial support from TED.com, my colleagues and I decided to create experimental facilities to examine the questions and conjectures I outlined above. We intend to create seven facilities where children can work with the Internet in unsupervised groups. We expect these children to use these very publicly visible facilities along with eMediators: teachers who can work with them via videoconferencing over the Internet. Of these seven planned facilities, five were operational as of May 2014. These facilities, called Schools in the Cloud, have been constructed in two remote areas in Bengal, India; one in a school for children from low-income families in New Delhi, India; and two in schools with excellent facilities in northeastern England (Figure 4). Two more are under construction in India. We located these schools in places where we could observe their functionality over a large range of socioeconomic and cultural environments. We will study their effects, if any, on children's learning and development over the period 2014–2016.

We have already assembled a group of eMediators, or members of the ‘‘Granny Cloud’’, and have been developing methods of learning using their presence over the Internet. This group uses a web platform (www.theschoolinthecloud.org) to connect with schools and children and carry out either conversations or SOLE sessions.

For children in remote areas, facilities designed along the above lines can replace traditional schools, once their design and pedagogy are adequately understood. For such schools to operate effectively, curricula, pedagogy, and examinations will all need to be suitably modified. Moreover, curricula need to be generalised to avoid referring to specific topics. The Common Core initiative in the United States (CCSSI 2014) is an example of an attempt to do so. I believe such curricula are amenable to SOLE methodology and can be triggered by activities suggested remotely. Consider this example from the core standards for grade 6–8 social sciences in the United States: CCSS.ELA-Literacy.RH.6-8.3. Identify key steps in a text's description of a process related to history/social studies (e.g., how a bill becomes law, how interest rates are raised or lowered).

Fig. 4 A School in the Cloud

Children at much lower grades can easily do this task through SOLE questions like these:

Why do people keep money in a bank?
What is interest?
What is an interest rate?
How and why are interest rates raised or lowered?

The pedagogy for learning in a School in the Cloud has, necessarily, to be self-organised. Lectures over Skype are not very likely to be effective with children. Such changes in curriculum and pedagogy can be achieved with least effort by changing the examination system. I suggested above, in the section on the history of primary education, that teaching practice had been changed by changes in technology, such as the introduction of paper or the use of assistive technology, such as rulers and compasses, in examinations. Introducing the assistive technology of our times into the examination system can cause a similar change. For example, learners could be allowed to answer examination questions using an Internet-connected device such as a tablet computer. Such a change will change the nature of questions in an examination. For example, consider the following GCSE question from the UK (http://image.guardian.co.uk/sys-files/

Education/documents/2009/03/05/exampaper.pdf):

> Greenhouse gases keep the Earth warm because...
> they are good insulators
> they trap energy as it enters the Earth's atmosphere from the Sun
> they allow more radiation to pass through
> they re-radiate energy back to the Earth

Anyone with access to the Internet can answer this question in seconds. On the other hand, what would happen if we were to change the question to this:

> What is Global Warming? What causes it, and can it be prevented? Develop a paragraph on this using the Internet and discussions with your colleagues.

Clearly a question like this would not only check the examinee's abilities to address complex issues, but would also promote his or her learning.

Using the Internet to examine has the potential to combine curriculum, pedagogy, and testing into a single activity.

Introducing such changes into schooling would require considerable changes in education policy. Policy-making bodies would need to consider several key ideas, including these:

Individual performance does not necessarily indicate the efficiency of an educational system.
It is not important for learners to ‘‘know’’ everything. It is important for learners to be able to find out what and how to know—effectively and in the shortest possible time.

Creativity is more important than ‘‘order and method’’. It needs to be measured as an important indicator of the efficiency of an educational system.
Imagination needs to be measured as an important indicator of the efficiency of an educational system.

Learning and chaos

The ways that children behave during SOLE sessions everywhere are reminiscent of self-organising systems. A self-organising system consists of a set of entities that exhibit an emerging global system behaviour via local interactions without centralised control (Elmenreich and de Meer 2008). Self-organising systems fall under the general area of chaos theory in physics. The definition of chaos can be applied to education in general: ‘‘A system whose long- term behaviour is unpredictable: tiny changes in the accuracy of the starting value rapidly diverge to anywhere in its possible state space. There can, however, be a finite number of available states, so statistical prediction can still be useful’’ (CSG 2007).

The sentence above may well sum up, in the language of physics, what we understand as education and assessment. Working with a group of children, a school cannot predict what will emerge at the end of schooling, but can make statistical predictions based on test scores.

In a SOLE, children seem to create and maximise meaning out of the information content of what they are researching. This, too, is uncannily close to the definition of the term ‘‘Edge of

Chaos'': ''the tendency of dynamic systems to self-organise to a state roughly midway between globally static (unchanging) and chaotic (random) states. This can also be regarded as the liquid phase, halfway between solid (static) and gas (random) natural states. In information theory, this is the state containing the maximum information'' (CSG 2007).

Finally, I believe the science of emergence offers a potential explanation of children's ability to read in groups above their individual capabilities. Emergence, a common phenomenon in nature, is the appearance of properties that are not evident in the parts of a system. Nebulas, flowers, cells, and markets all show emergent behaviour. Again, CSG (2007) provides a definition: ''System properties that are not evident from those of the parts. A higher-level phenomenon that cannot be reduced to that of the simpler constituents and needs new concepts to be introduced''. It continues, ''This property is neither simply an aggregate one, nor epiphenomenal, but often exhibits 'downward causation'. Modelling emergent dynamical hierarchies is central to future complexity research''.

Put into the context of SOLEs, we are attempting to create a dynamic system where each child is allowed to interact with all other children. This communication is more intense inside each group, but also occurs across groups. The groups themselves can be reconfigured, since children are allowed to change groups. Group sizes can vary over time and the structure is fluid.

The SOLE environment encourages the ''edge of chaos'' effect, since it is neither strictly ordered nor totally chaotic. This is very important for enabling emergent behaviour to appear, as it indeed does, frequently. Teachers often document this, using phrases like ''incredible what they found in such a short time''.

Complexity theory is in its infancy. However, it has the potential to explain not just how learning happens, but why it happens the way it does.

Consequences: A speculative discussion

Urban children, and increasingly those in other settings, are accessing the Internet through a host of devices that are all getting cheaper, lighter and smaller. It is entirely possible to imagine a situation in the near future where it would not be possible to detect whether or not a person was consulting the Internet. What will happen to examinations when the Internet is available to the examinee?

It is also imaginable that, using the Internet, a learner could ''pretend'' to be educated. By ''pretend'', I mean the learner could claim to know a subject that he or she has not been taught in the traditional sense. When children use SOLEs, in a sense they are doing just that. However, we must notice that the act of ''pretending'' eventually results in their learning the subject. In other words, when a learner practices a set of skills without being taught them but uses the Internet for support, she learns the subject, over a period of time. The learner becomes what she pretends to be.

Let us imagine a person claiming to be an accountant, who has no knowledge of the subject. Using the Internet, he solves accounting problems for his clients. He uses search engines, websites, and web-based tools and also consults people on the Internet through voice, video or text. In the first instance, he may look up the words ''balance sheet''. The next time, he would not look up those words because he would know what they mean. The Internet makes it possible for people to become self-made professionals, just as in another age people became self-made mechanics, electricians, etc.

What would happen to certification and qualifications in an Internet-immersive world? What would curriculum mean when learners have access to the latest in the field within minutes after it is published or spoken about? These questions challenge the fundamentals of traditional education: a system that has its origins in the colonial and industrial ages and whose purpose, by and large, is to produce identical people. That purpose itself is now obsolete and so, perhaps, is the system.

SOLEs are a first faltering step towards preparing our children for a future we can barely imagine.

Related Research

2002 Children and the Internet: experiments with minimally invasive education in India
2003 Minimally invasive education: a progress report on the "hole-in-the-wall" experiments
2005 ACQUISITION OF COMPUTING LITERACY ON SHARED PUBLIC COMPUTERS: CHILDREN AND THE "HOLE IN THE WALL"
2007 EFFECTS OF REMOTENESS ON THE QUALITY OF EDUCATION: A CASE STUDY FROM NORTH INDIAN SCHOOLS
2010 Limits to self-organising systems of learning—the Kalikuppam experiment
2011 Developing a curriculum based on SOLEs
2012 Children and the Internet – A Preliminary Study in Uruguay
2012 Collaborative learning amongst distance learners of mathematics
2013 SOLEs in England, a qualitative study
2014 The Gateshead experiments that led to SOLEs

Books

Mitra, Sugata (2012), Beyond the Hole in the Wall, Discover the power of self organised learning (eBook) TED Books, USA

Mitra, Sugata (2006), The Hole in the Wall: Self-Organising Systems in EducationTata McGraw Hill, New Delhi, now translated into Portuguese and Italian.

Gaurav Bhatnagar, Shikha Mehta, Sugata Mitra. (eds), (2002), Introduction To Multimedia Systems, San Diego, California and London: Academic

Videos

2018 V.O. Complete. The greatest answers about educations live in the questions, Sugata Mitra
2013 What's the future of learning in a networked society? Watch Ericsson's latest short film to find out.
2013 TED Prize talk: Build a School in the Cloud
2010 TED The child-driven education
2007 TED Kids can teach themselves

Websites

YouTube Channel
The Hole in the Wall
SOLEs and SOMEs website
The Granny Cloud
The School in the Cloud

The New York Times

One on One: Sugata Mitra, 2013 TED Prize Winner

By JOSHUA BRUSTEIN

FEBRUARY 27, 2013 5:53 PM February 27, 2013 5:53 pm
Sugata Mitra speaking on Tuesday

Are teachers keeping students from learning in the digital age? Sugata Mitra, a professor of educational technology at Newcastle University, believes so. Professor Mitra is best known for an experiment in which he carved a hole from his research center in Delhi into an adjacent slum, placing a freely accessible computer there for children to use.

The children quickly taught themselves basic computer skills. The "hole in the wall" experiment, as it is known, led Professor Mitra to develop the idea of learning environments in which teachers would merely be supervisors as children taught themselves by working together at computer terminals. On Tuesday Professor Mitra was given the 2013 TED Prize, which grants him $1 million to build a learning laboratory based on this principle.

Q. What did you learn from the original "hole in the wall" experiment?

A. The first thing to point out is that it was done 14 years ago, at a time when few children in India had access to computers. I noticed the rich parents saying that their sons and daughters must be gifted, because they were so good with computers. And since we know that gifted kids are not born only to rich parents, why would there not be similar children in the slums? I was curious to see what would happen if I gave an Internet- connected computer to the kind of kids who never had one.

We noticed that they learned how to surf within hours. It was a bit of a surprise. Long story short, they would teach themselves whatever they had to to use the computer, such was the attraction of the machine.

Q. What does this mean for education?

A. In those days, the main question was what does it mean for training, because back then people were trained to use computers. So I said it looks like we don't have to do that.

But I got curious about the fact that the children were teaching themselves a smattering of English. So I started doing a whole range of experiments, and I found that if you left them alone, working in groups, they could learn almost anything once they've gotten used to the fact that you can research on the Internet. This was done between 2000 and 2006.

I came to England in 2006, and the schools said, why aren't you doing it here? So I did, and I realized that what I've got has nothing to do with poor children. It probably is just a new way in which children learn in this new environment. It needs two things. First, broadband. That's fine, everybody loves that. The second thing is, it needs the teacher to stand back.

At first I thought that the children were learning in spite of the teacher not interfering. But I changed my opinion, and realized this was happening because the teacher was not interfering. At that point, I didn't become entirely popular with teachers. But I explained to them that the job has changed. You ask the right kind of question, then you stand back and let the learning happen.

Q.Do schools need to be radically changed to implement this, or is this a technique that fits into the current structure of schools?

A. At the moment I pitch it as a technique that you can bring into your schools. But that's not the real story, which is that the current schooling system is a leftover from the Victorian age of empire. In that world, there were no computers, no telegraphs and data was carried around on ships. This meant that the pillars of education were reading, writing and arithmetic. That age is gone. The system was wonderfully engineered, but we don't need it anymore; we need something else. But you can't just say that without saying how you do it.

What I'm doing is I'm putting my foot in the door by saying here's a new way. Try it. If you're happy with it, then I'll say let's look at the curriculum top to bottom. If we can convert the curriculum into big questions, if we can turn assessment into peer assessment, then neurophysiology tells us that learning gets enhanced. Finally, if you add admiration — what I call the grandmother's method, where you stand behind and encourage them. Put all of this together and you get a new way to do schooling.

Q. So it seems that you're saying we don't need teachers at all.

A. We need teachers to do different things. The teacher has to ask the question, and tell the children what they have learned. She comes in at the two ends, a cap at the end and a starter at the beginning.

Teachers are not supposed to be repositories of information which they dish out. That is from an age when there were no other repositories of information, other than books or teachers, neither of which were portable. A lot of my big task is retraining these teachers. Now they have to watch as children learn.

Q. Is there a problem with this in that it will serve the good students well, but leave those who need more coaching behind?

A. Well, yes, to some extent. But there are some interesting things about children working in groups if those groups are self-made. Once you let children do that, the system has a self-correcting ability. Having said that, will there be good students and bad students? Of course.

Q. Does this work for all levels of instruction?

A. It doesn't work the same way with adolescents, and definitely not with adults. With 8- to 12-year-olds, that's the age where big questions turn them on.

Q. What are your specific plans with the prize?

A. In order to see if this sort of self-organized learning environment is suitable I need to have one in which I have some control over and can do measurements with. So I want to build one of these learning spaces somewhere.

It will be totally automatic, completely controlled from the cloud. There will be a supervisor, but that person is not going to be a computer expert or a teacher in anything. She — and it will probably be a she — will be there only for health and safety requirements.

The rest of the school, if we call it a school, is a facility that I can hand over to a mediator from the cloud. She logs in from her home, wherever her home is, and she's able to control everything inside, the lights, the air-conditioning, you name it. Then there are four mediators who Skype in and use the pedagogical method. That's going to take a lot of work.

The second bit is that schools all over the world have been using this method. We need to do a massive multiplication, and TED is going to help me do that. I am going to try to put that into homes; get your children and their friends together. Then, every time they do it, I'll ask them to collect data and send it to a Web site. If I succeed, in two years I'll have massive data from all over the world. By that time I'll be done building the facility and I'll be ready to build a new model.

Q. Where do you think this school will be?

A. I'd like to do it in India, because I'd know how to get it done. There will be less of a learning curve, I know who the contractors are, and I know how not to get cheated. So I'd like to do it there, but it's not set in stone.

Using computers to teach children with no teachers
By Jonathan Fildes Technology reporter, BBC News, Oxford 16 July 2010
From the section Technology


The original experiment let children interact with a PC via a hole in a wall

A 10-year experiment that started with Indian slum children being given access to computers has produced a new concept for education, a conference has heard.
Professor Sugata Mitra first introduced children in a Delhi slum to computers in 1999.
He has watched the children teach themselves - and others - how to use the machines and gather information.

Follow up experiments suggest children around the world can learn complex tasks quickly with little supervision.

"I think we have stumbled across a self-organising system with learning as an emergent behaviour," he told the TED Global (Technology, Entertainment and Design) conference.

Learning curve
Professor Mitra's work began when he was working for a software company and decided to embed a computer in the wall of his office in Delhi that was facing a slum.

"The children barely went to school, they didn't know any English, they had never seen a computer before and they didn't know what the internet was."

To his surprise, the children quickly figured out how to use the computers and access the internet.

"I repeated the experiment across India and noticed that children will learn to do what they want to learn to do."


The experiment has been repeated in many more places with very similar results

He saw children teaching each other how to use the computer and picking up new skills.
One group in Rajasthan, he said, learnt how to record and play music on the computer within four hours of it arriving in their village.

"At the end of it we concluded that groups of children can learn to use computers on their own irrespective of who or where they are," he said.

His experiments then become more ambitious and more global.

In Cambodia, for example, he left a simple maths game for children to play with.

"No child would play with it inside the classroom. If you leave it on the pavement and all the adults go away then they will show off to one another about what they can do," said Prof Mitra, who now works at Newcastle University in the UK.
He has continued his work in India.

Stress test

"I wanted to test the limits of this system," he said. "I set myself an impossible target: can Tamil speaking 12-year-olds in south India teach themselves biotechnology in English on their own?"
The researcher gathered 26 children and gave them computers preloaded with information in English.

"I told them: 'there is some very difficult stuff on this computer, I won't be surprised if you don't understand anything'."

Two months later, he returned.

Many initiatives aim to put computers in the hands of children.

Initially the children said they had not learnt anything, despite the fact that they used the computers everyday.

"Then a 12-year-old girl raised her hand and said 'apart from the fact that improper replication of the DNA contributes to genetic disease - we've understood nothing else'."

Further experiment showed that having a person - known as "the granny figure" - stand behind the children and encourage them raised standards even higher.

Returning to the UK, he fine-tuned his method even further.

He gave groups of four children a computer each and set them a series of GCSE questions. The groups were allowed to exchange information and swap members.

"The best group solved everything in 20 minutes, the worst in 45 minutes."

To prove that the children were learning, and not just skimming information off the web, he returned two months later and set the same questions. Crucially, this time the children had to answer them on their own with no computer aids.

"The average score when I did it with computers was 76%. When I did it without computers, the average score was 76% - they had near photographic recall."

Professor Mitra has now formalised the lessons from his experiments and has come up with a new concept for schools called SOLE (Self Organised Learning Environments).
These spaces consist of a computer with a bench big enough to let four children sit around the screen.

"It doesn't work if you give them each a computer individually," he said.

For his experiments he has also created a "granny cloud" - 200 volunteer grandmothers who can be called upon to video chat with the kids and provide encouragement.

He has tested the spaces in the UK and Italy, with similar results, and now believes it should be tested more widely.

"We could change everything," he said.

THE WALL STREET JOURNAL.

Turning Kids From India's Slums Into Autodidacts
By Matt Ridley

Updated Dec. 4, 2010 12:01 a.m. ET

Everybody knows that the Internet will transform education, but nobody yet knows how. Most of the models sound like dull attempts to reproduce, at a distance, the medieval habit of schooling— one teacher telling a bunch of children what to think. Now, though, I think I have glimpsed a better idea: the self-organized learning environment (SOLE).

The credit for this approach belongs to Sugata Mitra, an Indian physicist who, a decade ago, began to install public "hole in the wall" computers in the streets of Indian slums. He then sat back and watched how quickly the impoverished kids learned to use the technology. The experiment, which has now gone global, inspired the book that inspired the film "Slumdog Millionaire," in which a boy from the slums improbably learns enough to win a TV quiz show.

Dr. Mitra's next brainchild, SOLE, takes this dynamic into the classroom. He is convinced that, with the Internet, kids can learn by themselves, so long as they are in small groups and have well- posed questions to answer. He now goes into schools and asks a hard question that he thinks the students will not be able to answer, such as: "How do you stop something moving?" or "Was World War II good or bad?"

He gives them no clue where to start, but—crucially—he insists that the school restrict the number of Internet portals in the class to one for every four students. One child in front of a computer learns little; four discussing and debating learn a lot. What happens next is entirely up to the students. All they know is that Dr. Mitra is coming back to be told what they have found.

He arrives with a second question that links the learning more closely to the curriculum, such as: "Who was Isaac Newton?" and then "What's the connection between Newton and stopping things moving?" The kids teach themselves the laws of motion. Of course, the Internet is fallible as a source, but so are teachers and textbooks. For the noncontroversial topics that make up the curriculum, even Wikipedia is pretty good.

In a village in Tamil Nadu called Kalikuppam, Dr. Mitra asked a class of poor Tamil-speaking kids to use the Internet, which they had not yet encountered, to learn biotechnology, which they had never heard of, in English, which they did not speak. Two months later he was astounded at what they had taught themselves.

In 2006, Dr. Mitra moved to England, became a professor of educational technology at Newcastle University, and tested SOLE in schools in a poor urban neighborhood, teaching teachers to be facilitators rather than pedagogues.
On their own, children can get about 30% of the knowledge required to pass exams. To go further, Dr. Mitra supplements SOLE with e-mediators, or the "granny cloud" as he calls it:

amateur volunteers who use Skype to help kids learn online.

The experiment is now going global. Schools in Australia, Colombia, England and India are trying SOLE and sharing their experiences of how to improve it. The U.S. has been slow to join, says Dr. Mitra, because Americans tend to view the program as relevant only to the developing world. But schools in Nevada, Maine and San Francisco have recently called on him to explain his ideas.

One of my philosophical passions is bottom-up order. Human beings have a hard time understanding that some of the finest complexity in the world comes about through spontaneous emergence, not top-down diktat. This is true of ecosystems and economies, of genomes and cultures, of embryos and encyclopedias.

Education, though, feels like one of those things that has to be top-down: There has to be a teacher and a taught. But plenty of people educate themselves. Is it possible for everybody to be an autodidact, now that knowledge is so accessible online?

—Matt Ridley's many books include, most recently, "The Rational Optimist" and "Francis Crick." His website is rationaloptimist.com.

Links to many other articles can be found here: https://www.cevesm.com/quick-links

Sugata Mitra
Curriculum Vitae

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Personal
Born in Calcutta, India on 12 February, 1952. Citizen of India, currently resident in Gateshead, UK.
Married to Sushmita Mitra, now retired from National Institute of Open Schooling (NIOS), Government of India. One son, Shounak Mitra , born in 1981, working as software engineer in Denver, Colorado, USA.

Education

- **Doctor of Philosophy (Ph.D.)** in the Theoretical Solid State Physics of Organic Semiconductors, Indian Institute of Technology, Delhi, 1978.
- **Master of Science (M.Sc.)** in Physics with specialisation in Quantum Biology and Acoustic Holography, Indian Institue of Technology, Delhi, 1975. First class
- **Bachelor of Science (B.Sc.)** with honours in Physics from Jadavpur University, Calcutta, 1973. First Class with second position in the University**.**
- **Indian School Certificate (I.S.C.)** awarded by the University of Cambridge, UK from St. Xavier's High School, Delhi, 1969. First Division.

Positions

Current: Professor and Principal Research Investigator, Newcastle University, UK
2013-16: Director, SOLE Central **and** Professor of Educational Technology, School of Education, Communication and Language Sciences, Newcastle University, UK.
2011-12: Visiting Professor, MIT Media Lab, Cambridge, Massachusetts, USA.
2006: Professor of Educational Technology, School of Education, Communication and Language Sciences, Newcastle University, UK.
1990 - 2006: Chief Scientist, Centre for Research in Cognitive Systems, NIIT Ltd., India's largest multinational training and software services company. Founded and heading the R&D Centre of the company and responsible for all innovations in education, computer applications, media and communications technology. Activities include management, research, teaching and writing. During this period (1990-2006), the company turnover increased from Indian Rupees (INR) 300 million to over INR 10 billion (US$250 million).
1987-1990: Director, Publishing Systems, United Database (India) Ltd., then India's larges telephone directory publishing company. Heading all technical functions including research and development. Activities included management, research and systems development. During this period, the company turnover increased from INR 35 million to INR 750 million.
1983-1987: Head, Technology Division, United India Periodicals Pvt. Ltd., publishers of daily newspaper, the Patriot. Responsible for all digital technology including research and development. Activities included management, research, teaching, writing and systems

development. During this period, the company turnover increased from INR 10 million to INR 30 million.
1982-1983: Manager, Product Development, National Institute of Information Technology. Activities included research, teaching and development of instructional material.
1981-1982: Senior Scientific Officer, Indian Institute of Technology, Delhi. Activities included research and teaching.
1980-1981: Research Fellow, Technical University of Vienna, Austria.
1979-1980: Research Associate, Indian Institute of Technology, Delhi.

Professional Experience

Research: Over 35 years' experience in Learning Systems, Educational Software and Instructional Design, Organic Semiconductors, Computational Physics, Energy Storage Systems, Living Systems, Publishing Systems, Neural Networks, Multimedia, the Internet, Cognitive Systems and Artificial Life.
Software: Conceived, designed, developed and implemented over 100,000 lines of code in Fortran IV and 7 dialects of Basic including Visual Basic as well as HTML.
Communication: Published over 35 research papers and over 1000 articles for adults and children in magazines and newspapers since 1965. Designed and implemented over 12 digital interactive multimedia applications. Played the lead instructional role in a 30 part Television serial on computers. Appeared in numerous technical interviews and instructional programs on Indian national and international television. Taught over 3000 students ranging from children to graduates and executives since 1975. Developed courses that have been used by NIIT and others to train over a million students all over the world.
Management: Established and managed the following:
-Computing Facility - the Centre for Energy Studies, Indian Institute of Technology, Delhi, 1982.
-Product Development Cell - National Institute of Information Technology, 1983.
-Technology Division - United India Periodicals, 1986
-United Database (India) - United Database India Ltd., 1987.
-R&D Centre - NIIT Ltd., 1990
-Centre for Research in Cognitive Systems (CRCS) – NIIT Ltd. 1999.
-Director of research, ECLS, Newcastle University, 2007-2009

Membership and Affiliations

- Vice President, All India Association for Educational Technology, India. (1993-97)
- Member, The Press Club of India
- Member, India Habitat Centre
- Member, New York Academy of Sciences, USA
- Member, Planetary Society, USA
- Member, Institution of Electrical and Electronic Engineers (IEEE), USA
- UNDP consultant, Indira Gandhi Centre for the Arts, India (1995-97)

Awards

- The National Science Talent Scholarship, 1969-1978.
- The National Merit Scholarship, 1969.
- The Indo-Austrian Research Scholarship, 1980-1981.
- The Raizada award for the best paper of 1999 from the Computer Society of India, 1999.
- The "Best ICT story" award from the IICD at the World Bank's Global Knowledge II

conference in Kuala Lumpur, March 2000.

- The “Best Social Innovation of the year 2000” award from the Institute for social inventions, UK, 2000.
- The “Man for Peace” award for 2002 from the Together For Peace Foundation, Italy, 2002
- Finalist, World Technology Awards, education category, World Technology Network, San Francisco, June, 2003
- The Dewang Mehta award for innovation in IT, Ministry of Information Technology, Government of India, 2005
- Best Education Research Article in an Open Access Journal for 2005, The Communication of Research Special Interest Group of the American Educational Research Association, 2006
- Alumni Award for Outstanding Contribution to National Development, from the Indian Institute of Technology, Delhi, 2006
- Best Book award from the Indian Society for Training and Development, 2007
- Honorary Doctorate, Technical University of Delft, the Netherlands, 2011
- Special Achievement Award, 'Learning Without Borders', 2011
- The Klingenstein Award, USA, 2011
- The Leonardo European Corporate Learning Award 2012
- The $1 million TED prize 2013
- Distinguished Alumni Award, Indian Institute of Technology, Delhi, 2013
- Honorary Doctorate, Open University, UK, 2014
- Honorary Doctorate, Siglio 21 University, Argentina, 2016

Principal Achievements

Conception, design, development and implementation of novel computer applications in India.

1983: India’s first Local Area Network based newspaper publishing system.

Configured and implemented a Burroughs B21 network connected to Autologic typesetters and programmed pagination rules in the pre-desktop publishing era. Also predicted the emergence of desktop publishing industry.

Ref: Computers Today, May 1985 (India). Copy available.

1985: India’s first automatic database publishing system.

Conceived and developed database publishing software and applied this to produce the Delhi Telephone directory.

Ref: Times of India, Saturday, December 10,1988, pg1 (India). Copy available.

1988: The world’s first PC-LAN based Yellow Page publishing system.

Developed the technology and applied it to produce the first telephone directories with Yellow Pages for the Indian cities of Agra, Bombay, Bhubaneshwar, Calcutta, Coimbatore, Delhi, Hyderabad, Madurai, Salem, Thiruchrapally and Vishakhapattanam. Subsequently transferred the technology to Bangladesh to produce the first directories of Dhaka and Chittagong cities. In effect, this technology started the database publishing industry in these parts of Asia.

Ref: Computers Today, October 1988, pg73 (India). Copy available.

1989: India’s first Perception Recording System

Invented a system to take continuous analog inputs from 16 users and produce a real-time graph on a PC, with several statistical modes. Used for qualitative perception feedback studies, the system remains one of the few of its kind in the world.

Ref: ET, May 29, 1991 (India). Copy available.

1990: The world's first hyperlinking software

Conceived and developed "Imaginet", a program to hyperlink application programs on PC s such that the user can move seamlessly from application to application. Subsequently used for producing the first multimedia applications in India.

Ref: Imaginet: An Associative, Non-sequential multimedia Storage and Retrieval System S.Mitra and Ajay Magon, Multmedia Computer and Communications: Technology, Application and Enterprise (INFOCOM '92), Tata McGraw Hill pg 20-30, November 5-7, 1992, Bombay (India)

Also: Sunday Magazine, August 11, 1993 (India). Copy available.

1992: The world's first on-line multimedia Operation Theatre Information System

Supervised the development and implementation of a PC-LAN based system that converts conventional patient records into multimedia (audio, graphics, video, etc.) in real time for providing support information to surgeons during heart-bypass surgery.

Ref: Computers Today, May 1993 (India). Copy available.

1993: India's first Interactive Television

Invented what is possibly the most inexpensive method for implementing interactive TV using a combination of hyperlinking, voice mail and VGA to video technologies.

Ref: Quality Inn, Kensington Terrace, Bangalore (India). Also, Citicable, NOIDA, U.P.(India).

1994: India's first computer-based edutainment course for children

Developed a model for edutainment and implemented it to teach children advanced concepts in computing including concepts on Graphical User Interfaces, Artificial Intelligence, Genetic Programming and Artificial Life.

Ref: Education through Digital Entertainment: A Structured Approach, Renu Ahuja, Sugata Mitra, Rashmi Kumar and Monica Singh, Proc XXX Annual Conference of the CSI, pg 187, Tata McGraw Hill, 1995 (India)

Also: Express Computer, Bombay, May15, 1995 (India). Copies available.

1995: India's first electroencephalic interface for PCs

Conceived and supervised the development of an amplifier and digitiser for electroencephalic signals. This small and inexpensive device can act as a EEG or ECG viewer for biomedical purposes. However, the present project is aimed at studying the use of this device as a possible user interface for PCs and neurofeedback training.

Ref: Telegraph, Calcutta, October 21, 1996 (India). Copy available.

1996: The world's first virtual university on the Internet

Developed the NIITNetVarsity, a virtual university on the Internet. While several universities have web sites, the NetVarsity is a simulated environment that has no physical counterpart. The project was completed in July, 1996 and was at that time the only learning environment of its kind in the world. Instruction in the NetVarsity is composed of "Skilletes", which are like "atoms" of instruction. Modules are constructed by joining combinations of Skillettes to each other. Ref: http://www.netvarsity.com

1997: India's first live Internet camera applications

Developed and implemented live cam applications for webcasting the proceedings of the Annual General Body meeting of the Confederation of Indian Industries. This was followed by a webcast of live open heart surgery at the Escorts Heart Institute and Research Centre.

1998: The world's first outdoor Internet kiosk for disadvantaged children

Conceived and developed an outdoor kiosk that provides Internet access to slum children in New Delhi as well as rural children all over India. Popularly known as the "Hole in the wall", this project continues to attract worldwide attention. The experiment has been reported in almost all printed and broadcast media in the world. Thousands of references available on the Internet.

1999: India's first wireless web cameras and guided robotic Internet vehicles

Led a team of researchers that built and tested wireless Internet robotic camera applications. Currently operational at the Qutab Minar in Delhi and the Char Minar in Hyderabad, India.

2000: India's first infra-red and/or radio frequency digital speech delivery device

Led a team of researchers that built and deployed solid state, digital speech transmitters and receivers for a museum application. Visitors would "hear" exhibits describe themselves as they are approached. Currently deployed at Bodh Gaya, Bihar, India and at the Ramakrishna Mission, Delhi, India.

2001-2006: Deployment of outdoor rural kiosks for children

Funded by the International Finance Corporation, the Government of Delhi, the ICICI bank and the Government of India, constructed "hole in the wall" kiosks in remote villages of India, Cambodia and all over Africa. Over a five hundred computers now (2009) exist in these countries in the open and over 150,000 children use these for self-instruction and entertainment.

2007-2009: Design, development and deployment of Self Organised Learning Environments (SOLE) for children

Funded by the education fund of Orient Global, designed and constructed 12 SOLE facilities in disadvantaged areas of Hyderabad and Sindhudurg, Maharashtra, India. Over 6000 children use these facilities for self organised learning. Resulted were tested in Newcastle, UK This resulted in the training of thousands of teachers all over the world in the period 2009-2013. Schools in every continent have started using SOLEs and the number of children impacted is likely to be in the hundreds of thousands. Most major newspapers and TV channels in the world have reported this work.

2009: Conception and deployment of a Self Organised Mediation Environment (SOME) for children

The Oscar winning film 'Slumdog Millionaire' was based on a book by the same name inspired by Mitra's 'Hole in the wall' experiments. This was reported in the Guardian UK in February 2009 and resulted in a large number of volunteers willing to help with children in remote areas. Using Skype and a website www.solesandsomes.wikispaces.com a 'cloud' of mediators interact synchronously with children in Hyderabad and Shirgaon. Results were tested and more than a dozen disadvantaged schools in India and Colombia.

2013: Design, Development and Deployment of 'Schools in the Cloud'

This project was made possible by the 1 million dollar TED prize of 2013. Seven experimental sites, two in the UK and five in India, will be set up and observed over a three year period.
Schools in the Cloud brings together the concept of SOLEs (Self Organised Learning Environments) and SOMEs (Self Organised Mediation Environments).
https://www.theschoolinthecloud.org/

Contributions to Science and Technology

Generally considered to have a wide and multidisciplinary view of communication and computer applications. The following ideas have, arguably, influenced computing paradigms:

1978: The relationship between the structure and function of organic molecules

Through an interesting thought experiment and a large amount of computation showed that

the properties of the Pthalocyanine group of molecules depend on their shapes more than on the constituent atoms. Later applied this thinking to automatic typographic design.
Ref: Crystal Structure Sensitivity of the Band Structure of Organic Semiconductors, S.C. Mathur and S. Mitra, J.Phys.C Solid State, Vol 12 No.2 1979 (UK).

1982: A correlation between location and sensitivity of human sense organs
A speculative concept connecting physiology and quanta that could be of seminal interest to robotics today.
Ref: A Correlation between the Location and Sensitivity of Human Sense Organs, A.K. Bannerjee and S.Mitra, Spec. Science and Tech. Vol 5 No2 pg 141, 1982 (Australia).

1983: A diagnostic method for computer programming training
A simple and powerful method that involves detection of bugs purposely put into a program. Currently used for software quality control in several companies including Motorola.
Ref: Sugata Mitra and R.S.Pawar, Data Training, Vol2, No3, February 1983 (USA).

1985: Distributed processing over Local Area Networks
One of the earliest methods for breaking down large computational and database problems into smaller segments for simultaneous processing by many small computers. Reduced the cost of database publishing hardware by several orders of magnitude.
Ref: Computers Today, October 1988, pg 73 (India).

1988: Hyperlinking
A concept for non-linear interconnection of “Hyper-screens” left over from application programs after they have completed execution. This gives a general framework for the development of almost all multimedia and virtual reality applications as well as a new and wider meaning to graphical user interfaces.
Ref: Imaginet: An Associative, Non-sequential multimedia Storage and Retrieval System S.Mitra and Ajay Magon, Multmedia Computer and Communications: Technology, Application and Enterprise (INFOCOM ‘92), Tata McGraw Hill pg 20-30, November 5-7, 1992, Bombay (India)
Also: Sunday Magazine, August 11, 1993 (India).

1991: The Virtual Organism
A concept that extrapolates beyond the Graphical User Interface to schemes that interact with a user in an organic, multisensory manner. Integrates Database management Systems, Multimedia, Neural Networks and Expert Systems using the Left and Right Brain model.
Ref: Artificial Intelligence and India, IEEE Asia Pacific Horizon, Jan’93-Mar’93, Pg54 (India).

1993: Effect of damage on Neural Networks
Started in the late eighties, among the first workers to suggest that artificial neural networks can be used to gain an understanding of brain malfunction in diseases such as Alzheimer’s.
Ref: Proc. 1994 IEEE/SMC Conference, Vol.1, Pg 989 (USA).

1994: Storage and Retrieval of Human Personality
Current work continuing on the intriguing possibility of a digital, multisensory personality system that would encapsulate the basic graphical, vocal, mental and attitudinal characteristics of a person.
Ref: Telegraph, Calcutta, Monday, May 29 1995 (India).

1996: The Cognitive User Interface
Using the psychological principles underlying human personality and communication, this is an attempt at constructing user interfaces that proact (instead of react) and adapt to human needs. This work is continuing.

1997: Meaning in Binary Strings

Using simple analytical techniques, this is an attempt to determine where "meaning" lies in binary string representations of media objects.
This work is continuing.
Ref: Dataquest (India), May 31, (1998)

1999: Minimally Invasive Education

A set of experiments that set out to investigate the processes by which children self-instruct each other in skill areas. The experiments involve constructing outdoor Internet kiosks in rural and semi-urban areas, particularly where economically disadvantaged children live. The children are exposed to the technology with no instruction whatsoever. It is observed that they reach close to the levels of city children with no difficulty. Additional effects such as management skills, social skills, behaviour changes and acquisition of the English language has been observed as well. This work is continuing.
Ref: Mitra, Sugata et al., (2005), Acquisition of Computer Literacy on Shared Public Computers: Children and the "Hole in the wall", Australasian Journal of Educational Technology, 21(3), 407-426

2006: Fractal Replication in Time Manipulated Cellular Automata

A computer simulation shows that connected systems with an 'imagined' future will reproduce images fractally. Could this be a basis for memory and consciousness. This work in continuing. Ref: Mitra Sugata and Kumar, Sujai (2005). 'Fractal Replication in Time Manipulated One- Dimensional Cellular Automata', Complex Systems, Vol. 16 (3). http://www.complex-systems.com/Archive/hierarchy/genlisting.cgi?vol=16&iss=3&vars=Menu_1_16=1&label=Menu_1_16&state=0.

2009: Self Organised Learning and Mediation Environments (SOLEs and SOMEs)

Developed the concepts of SOLE where children in groups manage their own learning. They are assisted by a 'granny cloud', a groups of mostly retired teachers who interact with the children over Skype.

2013: The School in the Cloud

Experiments with seven facilities, two in the UK and five in India, where children use Self Organised Learning Environments and the Granny Cloud to take charge of their own learning.

Research awards

Government of the National Capital Territory of Delhi, 2000-2006, $ 150,000 for experiments in the Hole in the Wall technology in Delhi Slums.

ICCR, Government of India, 2001-2003, $ 300,000 for experiments in the Hole in the Wall technology in Cambodia.

The Social Initiatives group, ICICI bank, 2002-2005, $ 50,000 for experiments in the Hole in the Wall technology in 5 villages in western coastal Maharashtra, India.

World Bank/International Finance Corporation, 2001-2004, $1.6 million for experiments in the Hole in the Wall technology in 23 Indian villages.

The Education Fund of Orient Global, 2006 onwards, $2 million for experiments in self-regulated education in remote and rural areas.

Knowledge Transfer Partnership, 2009-2010, about GBP 100,000 for a research project with ICS, Glasgow.

MIT Media Lab, 2011, $100,000 approx. funded by OLPC, USA, towards spending a year at the Media Lab.

The TED project, 2013: $1,000,000 towards the School in the Cloud project.

The Dalio Foundation, 2015. $150,000 towards maintenance of the School in the Cloud Lab in India.

Invited keynotes, plenaries, lectures etc.

Videos of some invited lectures:

First TED talk based on LIFT 2007
TED Global talk at Oxford, 2010
ALT-C 2010 Keynote
BBC Culture Show extract - 25 november 2010
A SOLE session at the Washington International School in February 2011
Google Zeitgeist 2011, London
http://www.youtube.com/watch?v=h6_YvNVzUZw&feature=youtube_gdata_player
Lots of talks all together
TED Book: Beyond the Hole In The Wall
TED Prize 2013 Talk
UNESCO talk of 2017
BBVA talk in Madrid 2018

Publications

Books
Mitra, Sugata (2012), Beyond the Hole in the Wall, Discover the power of self organised learning (eBook) TED Books, USA

Mitra, Sugata (2006), *The Hole in the Wall: Self-Organising Systems in Education*Tata McGraw Hill, New Delhi, now translated into Portuguese and Italian.

Gaurav Bhatnagar, Shikha Mehta, Sugata Mitra. (eds), (2002), *Introduction To Multimedia Systems,* San Diego, California and London: Academic
Journal Articles

1. Mitra, Sugata (2018) Book chapter - New Systems for Children's Learning: Changes Required in Education, in Handbook of Research on on Educational Design, IGI Global.
2. Mitra, Sugata and Dangwal, Ritu (2017) Acquisition of Computer Literacy Skills through self organising systems of learning among children in Bhutan and India, Prospects 2017, pp 1-18, Mitra and Dangwal
3. Mitra, Sugata (2016) The Future of Learning, Proceeding L@S '16, Proceedings of the

Third (2016) ACM Conference on Learning @ Scale Pages 61-62
4. Mitra Sugata, Kulkarni, Suneeta and Stanfield, James (2016) Learning at the Edge of Chaos: Self Organising Systems in Education, The Palgrave International Handbook of Alternative Education, pp 227-239.
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Indian Patent No. 217595	A fault tolerent computing system (2009)	Sugata Mitra, Sanjay Gupta, S. Minz

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