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Children and the Internet: Learning, in the Times to Come

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Abstract: It is proposed that the purpose of education is to enable people to live happy, healthy and useful lives — now and in the future. A curriculum and framework for children's education is derived from the above purpose. Using the results of over twenty years of research, the pedagogical and physical environments required that will enable children to learn are discussed in the post-pandemic world. Scenarios for schools and homes are presented with a special emphasis on the role of the Internet in children's learning. New methods for assessment and certification are described to complete a framework for children's education that is fit for purpose for our times.

Keywords: children's education, Internet, curriculum, pedagogy, assessment, certification, self-organization, SOLE, learning environments, pandemic.

Introduction

This article, an expanded and updated version of an earlier article on a web page for lay readers, describes a framework for children's education. As a result, the article has a somewhat conversational tone that readers are requested to kindly excuse.

This article, based on more than twenty years of research, is not directly related to the global pandemic caused by the COVID 19 virus from November 2019 to the time of writing (August, 2020). The framework described is a consequence of the change of age from industrial to information that humanity is going through. The pandemic has accelerated the pace of that changeover.

At this time, schools around the world are mostly closed and children are at home, as are their teachers. Traditional education is at a standstill, with the hope that, one day, the pandemic will be over and we will all 'go back to normal'. This is a desire to return to the past — a desire not uncommon in the design of children's education.

As for the virus, evolutionary processes, perhaps aided by a vaccine, will cause it to mutate into a benign steady-state, where it infects many but kills almost no one. This will ensure its survival and proliferation. This has happened before with viruses such as the common cold, or even influenza. We have adapted to living with these viruses. COVID 19 will join this list of survivors. Or, if it does not mutate quickly enough into a benign version, it will be eradicated like smallpox or polio.

While this happens, schools will reopen. I will start this article with what the reopened schools should look like, before examining why they should be this way. That examination will lead us to a framework for education that is suitable for our times. I have tried to identify references to work that supports my thinking as far as possible. However, for some of the most recent developments, such references do not exist and so the thinking needs to be inferential.

An Early 2021 Scenario

School does not look very different from the way it used to before the pandemic. It still has a front office, a staff room, the principal's office, corridors, spaces and classrooms. There are fewer people than there used to be. Everyone wears a mask, at least for the time being. Everyone stays a bit away from others.

There are fewer children at any time, about a fourth as many as there used to be. They do not have to wear masks, but many do. They do not all arrive together in the morning as they used to. Instead they come in four batches, through the day. The school day is about twice as long as it used to be.

Classes have between four and eight children, seated away from each other. A session, or 'period' as it is sometimes called, is 90 minutes long. These sessions sometimes have children who are physically present, sometimes mixed – with some children on the Internet and others physically present. Sometimes, a session is entirely virtual – only the teacher is present in the classroom, the children are on his screen. And sometimes, eerily, even the teacher is not present in the school, she is at home....

Sessions usually start with a set of questions. In the pre-pandemic times, this would have been called a test. Tests were usually given after the 'teaching and learning' were over. Not so anymore. Sessions can start with tests. The children have no idea what the answers might be, they haven't been 'taught'. But they can look up things on the Internet and talk to each other. When the answers come in, the teacher begins a discussion. She encourages the children to talk about their answers, sometimes, very occasionally, she adds a bit. They arrive at a consensus by the end of the session about what the answers are and why. The session ends. Sometimes the teacher encourages them to look further on their own – if they would like to and if they can. In the post-pandemic world, the 'teaching-learning-testing' sequence from the past is turned over into 'testing-learning-teaching'. Each session is a complete cycle. A 90-minute semester.

Each teacher handles four groups of four children over four, 90-minute, sessions every day. The timetable looks very different from the way it used to. There is outdoor playtime with no more than eight children at a time. There are tests and examinations once a month, these can be answered from class or home. The Internet is allowed during all tests, as is discussion – among children or between children and adults. Each child predicts his or her score before a test. As time goes on, their predictions get better. They learn how to accurately estimate what they can do; with the resources and time they have. This ability will help them greatly in the times to come.

The Internet equalises learning at school or home. The School in the Cloud extends across space from home or school. It works the same way in the school or at home, whether physically, mask-to-mask in the classroom, or virtually across homes. 'Lock-downs' do nothing to the School in the Cloud.

Education in the Pre-pandemic World

The education system came from the Military-Industry-Doctrine driven Age of Empires that we emerged from only in the mid-twentieth century. An age that required millions of identical people to do the jobs that machines do now. An age that required people to memorise what we can now access instantly from the Internet. An education system driven by examinations looking to see if children had been sufficiently 'sanitised' so that they know the same things and behave the same way. As the

world transitioned into the information age, it became evident that the existing education system was no longer fit for purpose. Then, in 2020, a virus shut the world down.

Education and the Pandemic

When the SARS-COVID-19 virus spread through the world, schools were shut down and children sent home. The Internet, so far resisted by schools, became our only ally during global lock-down. Children and the Internet are friends (Mitra et al, 2005), so teachers finally began to gather children together into Internet video conferences. But they made some mistakes.

Classrooms tend to have between 20 and 30 children because a room large enough to hold about 25 children packed in rows and columns is the maximum where a teacher can be heard clearly without any voice amplifying devices (ethicalpolitics.org, 2020). Its design is from 2000 BCE!

A class 'period' of teaching is usually about 45 minutes because that is about the maximum time a human being can talk loudly and continuously without lapsing into nonsense or a coughing fit.

Children were to attend school until they were seventeen. Because, in a military-industrial society, this is the age they are strong enough to work in factories, offices and armies.

Lecture followed by lecture with examinations in between. That was the model of the factory schools of the age of empires.

During the pandemic, teachers started to create groups of 25 children to form virtual 'classes' over the Internet. Then they lectured them, or, worse still, played them recorded lectures. It didn't work.

In these virtual classes, it is not possible to tell who is attending. Recently, a child changed his login display name to 'Reconnecting....'. Even more difficult is to figure out who is paying attention. The face that you see on your screen may be a few seconds in the past, or a photograph, or just a made-up expression. You may remember, there were equivalent problems in the old system as well. Even more tricky is the problem of whether parents will pay any fees for a lame, make-believe 'class' on the Internet. We need a different kind of class, one that children like to attend and pay attention in. Parents will pay for that.

Post-pandemic Education

When schools reopen, there is a distinct possibility that we will try to go back to school as it used to be —producing identical people for obsolete armies, factories, and offices. This will take the least effort and keep governments happy.

On the other hand, if we focus on the future rather than the past, we can design a hybrid system, partly physical, partly virtual, with assessments that are focused towards the ability to create things and solve problems.

Whatever option we choose, there is a rather rare opportunity to design an education system suitable for our times.

Some Things We Have Come to Know about Learning

There are existing theories about children and learning from thinkers such as Piaget, Vygotsky or Erikson, among many others (see for example, Cherry, 2020). This article is not about the application of those theories. What I will do is to highlight some findings from recent times that relate directly to children and the environments they are in today.

We know, from John Hattie's work (Hattie, 2012a), what affects children's learning in positive and negative ways. We even know which influences count more than others (Hattie, 2012b).

At the top of the list of positive influencers for children's learning is 'collective teacher efficacy'. This means if all the teachers in a school believe that they can, together, enable children to learn better, then, the children do learn better. The collective, like a hive, can do what individuals cannot.

Another important influencer on Hattie's list is "Self-reported grades". Here, a learner tells you how well she has understood a topic. You, the teacher, can then compare this with what you think her score should be. Or you could test and see if the test score matches her estimate. If a student exceeds her own expectation, her confidence and interest will rise, or so we expect. A well-known education innovator, Yaacov Hecht, uses a method (Hecht, 2017) that I find impressive. Each learner has a red, yellow and green card. During a learning session, each learner puts one of the cards in front. It is a visual clue that tells you, 'I've got it' (green), 'It's OK, I am getting it' (yellow) or 'Sorry, I haven't a clue' (red). The teacher and, indeed, the learner's peers now have an idea of the state of mind the learner is in. A learner with green is someone you could ask for advice. A learner with red needs a bit of help.

The next important influencer is 'Micro teaching'. Here, a lesson is either viewed or taken followed by a debriefing by the learners. What did they learn? What was the point? Could it have been put more simply? This is a cathartic experience for both teachers and learners and would improve both teaching and learning.

Related to micro-teaching is an influencer in Hattie's list called "classroom discussion". This is a general discussion about a topic by the whole group. This is powerful as it relates not just to comprehension but to communication as well. Discussion increases interest in a topic, almost immediately. Discussion among learners is a highly effective method of communicative learning that we will see later in the method called "Self-Organized Learning". In 2002, I met Sir Arthur C. Clarke. He mentioned that the important thing he had observed while watching videos of my "hole in the wall" experiments (Mitra & Rana, 2001), was that the children were interested in exploring the Internet. "When children have interest – education happens", he said.

Close to the bottom of the list of negative influencers is one called "Boredom". Boredom has a high negative influence on learning; it is more damaging to student learning than lack of sleep, low socio-economic status, corporal punishment, and depression (Weinberg & Brumback, 1990). Learners get bored if they don't see the point of what they are learning. Teachers get bored if they don't believe what they are teaching is important. For example, why should you know about tectonic plates? If you are not aware of the big unknown things about the earth's geology, you are unlikely to think tectonic plates are worth spending any time on. Any topic needs to start with the big questions that started people thinking about it.

The environment in which learning happens affects the efficacy of learning. This is rather obvious but has been downplayed for centuries. The work of Stephen Heppell (Heppell, 2020) is simple and important for a practical understanding of how to design learning environments. Temperature, sound, light and several other factors contribute to learning efficacy, or otherwise. Here is a summary of Heppell's work with a few additions of mine:

- Temperature: 18-21° Centigrade (about 64-70° Fahrenheit) is optimal, says Heppell (2020). Well, I think that may be so in the temperate climes but not in the tropics or near the equator. About 24°C is what children would find comfortable in the warmer climates. The temperature we find comfortable is often related to the ambient temperature. If it is 35°C ambient, then most children would find even 32°C to be quite comfortable. I once put an air conditioner in a village room in India, in summer. It was set to 24°C. In a few minutes, children started running out saying, "It's so nice and warm outside". Anyhow, it is important to have a comfortable temperature in your learning environment.
- Light: Between 500-1000 Lux is what is suggested by Heppell (2020). He also cautions against fluorescent lights. Bright LED is possibly the best bet. Learners go off-task in dim light and a bit hyper in really bright light.
- Movement: Children need to move, every so often, to get the blood flowing. Let them get up and do things. I often tell them to walk over to others to see what they are doing. They think this is funny advice.
- Colour: Coloured walls can be distracting. Cream or white is best, they also reflect and reduce the electricity bill. Bits of colors with wall hangings or cushions will reduce monotony.
- Carbon Dioxide: This gas can directly affect children's attention and increase disengagement. Keeping a few windows open, or a fresh air setting on an air conditioner will help. Indoor plants, plenty of them, also bring down the levels of CO_2 in the daytime.
- Noise and music: External noise is obviously avoidable. Properly designed doors and windows can help reduce noise. Music will help if it is very soft and instrumental. No vocals.
- Smells: The right smells can actually help with memory and concentration! I know too little about this to be more helpful. What is important is to keep strong smells out.

There are a few things I did not find in Heppell's work:

- Humidity: Heppell does not mention this but I think it is important. Too much and the sweat gets in the way of doing anything, too little and the children start to shrivel up and get headaches. About 60% is just right, I would guess but it is only a guess.
- Flooring: Easy to clean flooring that does not throw up dust is important for cleanliness and also to keep insects and germs out. Synthetic flooring is good and, if you choose right, will also have enough 'give' so that children don't get hurt if they fall. Carpets are not a good idea, no matter how nice they look.
- Wiring: All electrical wiring should be covered. Ducts running a few inches off the floor and along the walls are easy for maintenance and also safe. Below the floor, or up inside a false

ceiling is not a good idea, particularly in warmer places. I know a place where both snakes and mice find it exciting to move along underground ducts carrying wires.

- Computers: All-in-one PCs with screens of 19 inches or more (diagonal) are the best for children. Laptops, if you must, should have large screens that everyone can see from a distance. Smart phones are not at all a good idea in learning environments.
- Internet: Broadband at 20 Mbps or more is required for most video conferencing and multimedia browsing. Direct connections from the modem are preferable as they are steadier than WiFi for the computer used for videoconferencing. For other computers used just for browsing, WiFi is preferable as it reduces the amount of wiring.

Both Hattie and Heppell seem to have left the Internet out of their reckoning. I find this disappointing because I think the Internet is the most important influencer of learning in the world today. My work for more than twenty years has been on children and the Internet (Mitra, 2020) The key findings (Mitra, 2020) are summarised below:

1. Groups of unsupervised children, given access to the Internet in safe and publicly visible spaces, can figure out how to use the Internet, irrespective of who or where they are. We call this Minimally Invasive Education (MIE).
2. Groups of unsupervised children, given access to the Internet in safe and publicly visible spaces, can learn anything by themselves. These are called Self-Organised Learning Environments (SOLEs) (SOLE, 2020; Start SOLE, 2020).
3. The presence, physically or virtually, of a friendly, encouraging adult, enhances self-organised learning as listed in #2. Such intervention, when through the Internet, is called "The Granny Cloud" (Mitra, 2009; thegrannycloud.org, 2017).
4. Minimally Invasive Education, implemented through Self-Organised Learning Environments and the Granny Cloud, is called a School in the Cloud (Mitra, 2020; theschoolinthecloud.org, 2020).

You can set up a SOLE session with between four and 24 children. If you are planning to conduct one physically, you will need a room with the children and one computer connected to the Internet for every four children. Do not make too many computers available. Let the children make their own groups. They may make groups of more or less than four — let them. Tell them they can change groups whenever they want.

Now, frame whatever the learning objective is into a question. The question needs to be big and interesting. Not necessarily complex. For example, "How does your phone know where you are?" as an introduction to GPS and trigonometry. Or, "How do we see with our eyes closed, when we dream?" as an introduction to psychology.

Once you have set up the question, ask the children to work on the answer by themselves for about 30 minutes. Then get them to discuss the answers and come to a consensus on what they would present as the answer or answers. Finally, summarise their findings, congratulate them and close the session. Do not value add. If there are things missing, make another question for the next day. In a future that

is increasingly unimaginable, you can only encourage the children to explore things that you, many times, don't know.

'*You go there, I will go with you*', is your new role.

You can do SOLEs over the Internet, but with four or, at most, eight children. Use a video conferencing facility like Zoom or MS Teams or Google Meet – there are more appearing every day. A SOLE over the Internet will work just as well as one done in a classroom, if the group sizes are right.

In a SOLE, the Internet does not replace a teacher, it provides inputs that promote discussion and raises the interest of children in whatever they are looking for. When children have interest – education happens.

In the language of physics, Self-Organising Systems move from chaotic disorder to Spontaneous Order. Sometimes, this is called Emergent Behaviour – it is not planned or programmed; it just happens. 'Learning' and 'Knowing' could just be examples of Emergent Behaviour in Self-Organising Networks of the brains of children.

Using environment designs from Heppell's guidelines, using pedagogical influences from Hattie, and using SOLEs, we are ready for a new kind of learning that can work just as well from home, over the Internet, as it can in school. The question is — What should the children be learning?

Attempting to answer that question will lead us into the very basis and purpose of education itself.

What Should Children Learn?

It is difficult not to look back at your own childhood when trying to list what children should learn. This is perhaps the reason why curricula and the education system itself is outdated in most countries. Children's education is considered of great importance and its planning is left in the hands of senior, and often elderly, people. Such planners look back at their own childhoods of many decades ago and think of the good things they learned and the good things that they should have learned but did not. Another thing planners tend to do is to look at their grandchildren. As a result, many a country ends up with curricula and schools based on ideas of people with ancient experiences and angelic granddaughters. Then there are the parents and they, too, want their children to be educated the way they were educated. In other words, we prepare children for our past rather than their future. It is in this environment that we need to find out what children should learn. It is difficult to find published evidence of all this, hence, I leave it as conjecture.

What follows is an attempt to design a system that does not drag us back to the past.

Let me start by saying that we want children to live happy, healthy and useful lives. I hope there is nothing to argue against that wish. We might debate about what happiness, health and usefulness mean in different contexts, but we are not going to say we don't want children to live happy, healthy and useful lives.

If that is so, children must learn how to stay alive and be happy, healthy, and useful. That gives us a list of four things—living, happiness, health, and usefulness. All that follows in any education system —pedagogy, curricula, and assessment, must focus on these four things. Whenever they do not, we are going off-track.

The four things that children need to learn can be expanded to include one more level of detail for each of the four:

- To live, some understanding of safety, nature and technology are needed. We could add others, but I think it would be simpler if we work with these three and any additions can be included under one of the three.
- To be happy, some understanding of the Self, of Others including non-humans, and of our senses, art and music are needed. If I have missed some areas, we can add them under these three.
- To be healthy, some understanding of the body, disease, ageing, reproduction and exercise are needed. Like before, any other topics or areas can be added under these five.
- To be useful. This is the most complicated of the lot. But again, to avoid a combinatorial explosion, I decided on five areas— skills, behaviour, attitude, ethics, and knowledge.

To live happy, healthy and useful lives, children need to engage with the 16 areas above. We could take these areas and build a curriculum with them.

Curriculum

Curriculum can be defined as everything that happens, in educational processes, to a child in the schooling years (Wikipedia, 2020). It is usually a set of learning goals mapped across grades and time throughout the K-12 (that is, primary and secondary) school programme.

These learning goals are, obviously, things children need to know, as in the section above. They need to know these things for living happy, healthy, and useful lives. But there is one strange problem with this way of describing things that children need to know. Some things seem to get left out.

For example, a child could live a happy, healthy and useful life without knowing that the square root of minus 1, is an imaginary number. Or that sloths can hold their breaths longer than dolphins can. Or even that we live in a solar system in a galaxy. Many people do not know these things and live perfectly well. It is just that, for some strange reason, we like to know these strange, apparently useless, things. Children seem to love them and will stop in their tracks and drop everything they are doing to learn these things. For some reason, evolution has wired our brains, and the brains of many living things, for curiosity. Just in case, if someday these things become very important for some reason unknown.

So, I am going to divide the learning objectives of a curriculum into two categories – things that we need to know and things that make us feel good to know. Sometimes, different aspects of the same thing can fall into both categories. For example, we need to know that broken glass can be dangerous and that wine glasses can break if hit with a metal object. But it feels good to know that wine glasses filled with different levels of water can be played like a xylophone, with a metal spoon.

What follows is a curriculum. It is in general terms and any additions can be made as details for one of the heads already mentioned. Figure 1 shows the structure of the curriculum for the ‘need to know’ part. An identical structure will be used for the ‘good to know’ part of the curriculum. One more level of detail for both parts are included in the text that follows:

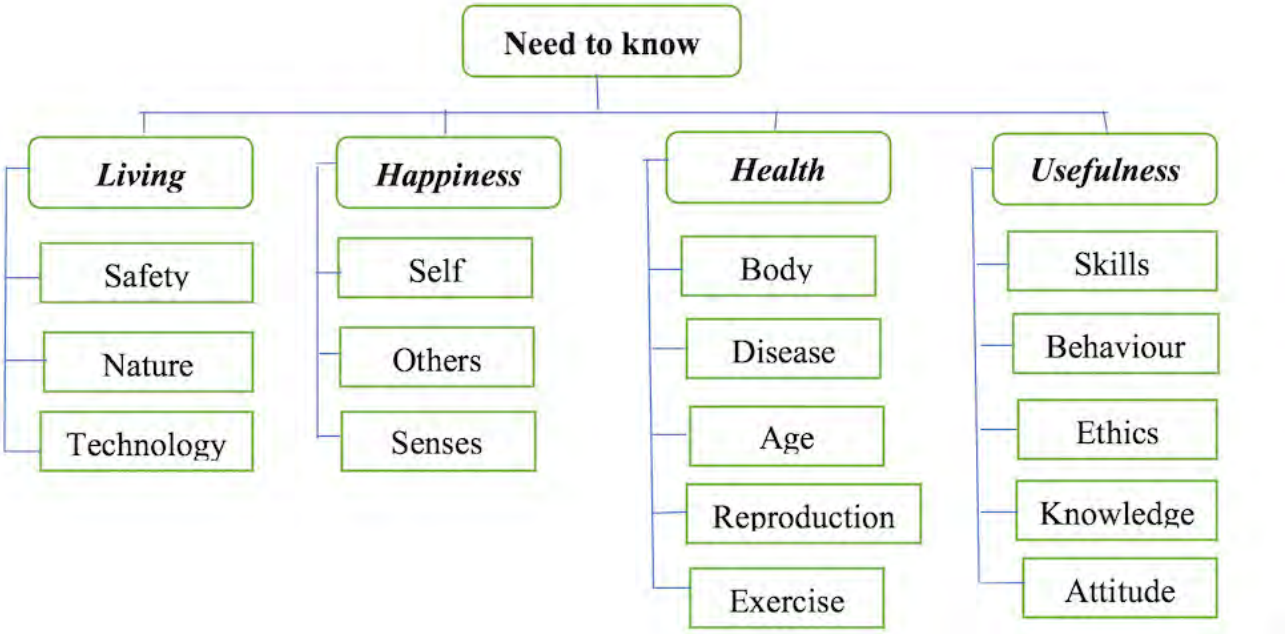

Figure 1: Structure of the 'Need to know' part of the curriculum. There will be an identical structure for the 'Good to know' part.

1. **Need to know:**

1.1 ***For living*** – treat all subtopics from the point of view of life and living.

1.1.1 Safety

- Walking, running, sitting, standing, jumping, sleeping, breathing.
- Defence, offence, hiding.
- Shouting, abusing, threatening.
- Eating, drinking. Disease. Teeth, gums, bones.
- Cuts, burns, bruises, aches and pains.
- Toys, switches, wires.
- Glass, metal, wood, plastic, rubber, bricks, concrete.
- Smoke, smells, sounds.
- Weather and clothing.
- People, animals, birds, fish, insects, reptiles.
- Cars, cycles, airplanes, ships, boats.
- Computers, smartphones, Internet, games.

1.1.2 Nature

- Fire, water, earth, air.
- Plants, trees. Animals, birds, insects, reptiles, fish.
- Weather and climate.

1.1.3 Technology

- Cars, buses, trains, planes, ships, boats.
- Electricity.
- Computers, Internet.
- Medicines, hospitals.
- Guns and weapons.
- Webcams, CCTV.

1.2 ***For Happiness*** – treat all subtopics from the point of view of happiness.

1.2.1 Self

- Meditation, feelings, emotions.
- Illusions.
- Desire, anger, greed, ego, jealousy.

1.2.2 Others

- People, plants, animals, etc.
- Life, pain, death.
- History.
- Friendship, love.
- Competition.

1.2.3 Senses

- Sight, sound, smell, taste, touch.
- Music, art, dance, drama, literature, poetry.

1.3 ***For Health*** – treat all subtopics from the point to view of health.

1.3.1 The body

- Biology, physiology.
- Brain, nervous system.
- Aesthetics and beauty.
- Other bodies, animals, etc.

1.3.2 Disease

- Wear and tear, germs and infections.
- Causes, prevention, medicines, doctors, hospitals.

1.3.3 Age

- Order, disorder, entropy.
- Maturity, death.

1.3.4 Reproduction

- Gender, sex. Birth.
- Other species.

1.3.5 Exercise

- Calories, fat, muscle.
- Aerobics, yoga, intensity, stamina, sports.

1.4 ***For Usefulness***—treat all subtopics from the point of view of usefulness in life and society.

1.4.1 Skills

- Comprehension, communication, computing.
- Making, fixing, repairing.
- Money, management.

1.4.2 Behaviour

- Language, politeness, manners, expression.
- Kindness, helpfulness. Pragmatism. Respect.

1.4.3 Ethics

- Right, wrong, truth, beliefs.

1.4.5 Knowledge

- Science, technology, engineering, mathematics.
- Statistics, economics, psychology, arts, philosophy, politics.

1.4.6 Attitude

- Positivism, patience, determination.
- Calmness. Humour.

2. Feels good to know:

2.1 ***For Living*** – treat all subtopics from the point of view of cool, nice to know.

2.1.1 Safety

- Dress, fashion, restaurants, shopping, gossip.

2.1.2 Nature

- The universe, biodiversity, oceans.

2.1.3 Technology

- Games, robots, drones, remote controlled vehicles.
- Telescopes, microscopes.
- VR, AR.

2.2 ***For Happiness*** – treat all subtopics from the point of view of fun to know.

2.2.1 Self

- Dating, drinking, smoking.

2.2.2 Others

- Aggression, violence, vandalism.

2.2.3 Senses

- Pornography, abusive language, substance abuse.
- Junk food.

2.3 ***For Health*** – treat all subtopics from the point of view of alternatives, and fun things.

2.3.1 The body

- Evolution, anthropology, races.

2.3.2 Disease

- Alternative medicine, superfoods.

2.3.3 Age

- Rejuvenation, immortality.

2.3.4 Reproduction

- Sex drive, testosterone, etc.

2.3.5 Exercise

- Body sculpting, diets, adventure sports.

2.4 ***For Usefulness*** – treat all subtopics from the point of view of quick money and street smartness.

2.4.1 Skills

- Tricks, DIY, cooking. Violence.

2.4.2 Behavior

- Poses, body language, non-verbal communication.

2.4.3 Ethics

- Manipulation, lies, emotional blackmail.

2.4.4 Knowledge

- Social media, 'general knowledge', the underworld, unusual facts.

2.4.5 Attitude

- Smart, cool, street smart.

This is a skeleton that you, or a committee, could flesh out with more detail. It can produce 21st-century individuals capable of taking the decisions that will enable them to live happy, healthy and useful lives.

Whether you accept the curricular framework above, or build your own, or accept one from the government – you will need to know how children will learn (pedagogy), how you will know they have learned (assessment) and how you will let other people know that they have learned (certification). This is the process of education and, in view of the recent pandemic, it needs to continue in equivalent ways, whether children are physically in school or not.

Pedagogy

Self-Organised Learning Environments (SOLE)

SOLEs are mentioned several times in the sections above. They are powerful methods for improving comprehension, communication, and computing skills in children in any subject area. In a SOLE, children in groups of about four, research a topic or a question using a shared Internet connection. They can change groups anytime, walk around and see what other groups are doing and talk as much as they like. SOLEs are conducted in safe, publicly visible spaces where all the activity is visible to everybody. In a SOLE, a topic is converted into a question, the answer to which should cover most of what is known on the topic. Sometimes, these questions may have no answer, or have multiple answers. Those are the best of the BIG questions that can drive SOLEs. Children, and most adults, love the unknown. You can take any topic from the curriculum above and make a big question out of it.

For example, from 1.4.1, 'What was the world like before money was invented?' or, from 2.1.1, 'Why does red go with black when dressing up?'

SOLEs conducted over the Internet are a little different from the ones conducted physically. In a physical SOLE, the ideal number of learners is 24, working on six computers. The ideal duration is 60 minutes. In an Internet SOLE, the ideal number of learners is four, that is about as many as you can comfortably see in front of a camera. Looking at the learners is important for SOLEs. You can't really see 24 postage-stamp-sized faces on a tiny screen and get any sense of presence. Also, on the Internet, you need to budget for some setup time and connectivity glitches. I would recommend the duration for a SOLE over the Internet to be 90 minutes.

SOLEs were invented in Gateshead, England in 2007. They started spreading into the schools of the UK, shortly afterwards. (Ofsted, the UK government body on education, mentioned SOLEs in 2012. (Ofsted, 2012)).

By 2015, SOLEs had spread throughout the world (theschoolinthecloud.org/, 2020).

Fabrication Labs

These are often called "FabLab", although many countries have different names for them (fabfoundation.org, 2020). These are spaces where children can make things. Not just paper and scissors kind of things, but electronic circuits, 3D-printed parts and so on. Groups of children can collaborate to make even complex things like drones or robots or plant watering systems. SOLEs coupled with Fab Labs can help children design and build really useful things.

Play

It is well known that play is among the most powerful methods for children's learning and development. It may be noticed that SOLEs and Fab Labs are actually forms of play. Use play for any part of the curriculum that you can design play for.

Talk

The lecture is one of the oldest methods for learning. Someone who knows tells others who don't. The others listen and learn. This has worked for millennia and is effective when used correctly. We know now that lectures are not effective where learners can easily figure out the content by themselves.

Discussions, debates, and presentations are other forms of talk-based learning that are powerful tools for learning. A group of learners gathered around a teacher is the oldest symbol of education in the world. It is possible to create such groups over the Internet. I would suggest not to exceed eight learners in any group. The duration of sessions needs to be about 25% more when on the Internet. You need to speak slowly and clearly. Repeating ideas a few times is also good practice on the Internet as you have no way to gauge attention levels or bandwidth fluctuations.

A judicious mixture of SOLEs, Fab Lab, play and talk is the best of the pedagogy we have available today. Of these, SOLEs and talk are possible over the Internet and will work just as well as in a physical school. Play needs to be designed differently for home, as also construction projects. Use whatever is available at home. Use your imagination!

Assessment

Did it all work? Did learning happen? Will it last?

Finding out if the learners gained from your efforts as a teacher, a parent or a principal is the most contentious, debated, criticised and even hated of all aspects of education. Children can be, literally, driven out of their minds by assessment. To add insult to injury, examinations are notoriously ineffective at predicting the future achievements of learners. The only use of 'end-of-school' examination results is mostly to determine if the learner is suitable for admission to a university. This can result in the Educated Disgruntled. The lawyer who wanted to be a chef, the nurse who wanted to be a pilot.

Every human being has a list of things they like to do, a list of things they are good at doing, and a list of things they actually do. Try making the three lists for yourself and you will probably see that the lists often don't match. Many go through life doing the things that they neither like to do nor are good at doing. Many others do the things they are good at doing but don't really like to do. We end up with disgruntled bus drivers and irritable doctors.

My Indian School Certificate, granted by the University of Cambridge in 1968, lists only seven subjects – English Language, English Literature, Hindi, Maths, Physics, Chemistry and Geometry. There is nothing in my school certificate that even hints at what I might be able to do well.

Most existing assessment systems are designed to fit people into slots in a social system, regardless of what they would like to do or become. We don't have social systems like that anymore, fitting people where they don't belong can be lethal in the world we are in.

What should we assess and how?

There is not much point in finding out how much a child knows in a world where 'knowing' is not quite what it used to be. 'I don't need to know everything, I just need to know where to find it when I need it', Einstein is supposed to have said. Whether he did or not, the sentence is prophetic.

No one really knows what 'knowing' means. If you listen to a song, do you now 'know' it? What about lectures, do you 'know' the contents once you have listened to them? Can you explain to someone what 'knowing' how to ride a bicycle means?

We do not know much about knowing—it's just something a brain does, when it wants to.

In a world where the Internet is instantly available to most people, you don't need to know things in advance. In our schooling system, children are expected to know a lot of things – just in case they ever need it. The children, quite rightly, feel that it is unlikely that they will ever be in dire need for, for example, a modal auxiliary verb. They disengage. Now, what if that child did encounter a situation where it was vital to know what a modal auxiliary verb is? Well, they could just look it up on Google. I once described this process as 'the end of knowing'. Nicholas Negroponte of MIT said, 'knowing is obsolete', after listening to a lecture in 2012.

We should assess whether children can solve problems and answer questions using the Internet. Taking away the Internet from children and then asking them to answer questions and solve problems

is like asking someone to tell the time of day without looking at their watch. It's pointless. We are not in the age of Robinson Crusoe, and we don't need the education from that age. We all use the Internet all the time, to do almost anything. Our children should do the same.

Sometimes, these suggestions are interpreted as resulting in children with blank brains and a smartphone in their pockets. Fortunately, the brain is not designed to remain blank. Our brains remember what they want, understand what they consider important, and learn (even 'know') what they think is worth learning. We try to control these processes through education but have no control over what actually happens inside the trillions of connections that form the network we call the brain. It is a self-organising system that moves from one spontaneously ordered state to another – always at the edge of chaos (Weinberg & Brumback, 1990).

In traditional education we try to load the brain with everything we know, just in case some of it is retained and used.

When children learn continuously off the Internet, the brain absorbs and retains what it considers important. When you Google something once, you usually don't Google it again. This form of learning is just in time, instead of just in case. It is patchy and spread over time. It is incredibly useful in a rapidly changing world.

Wherever we get our information from – the Internet, books, films, voice, gesture and so on, we need three basic skills to make use of it. Comprehension, communication and computing. We should be able to comprehend the input (that is, make sense of it), communicate the idea to others (people, machines, animals, etc.) and we should be able to compute the solution to problems using information. I use the word 'compute' here in the sense of not just computers, but the English sense of 'to reckon'.

Here is what we should assess about children's abilities:

Comprehension

- Answering questions about a subject.
- Applying subject knowledge, acquired from anywhere at any time, to solve a problem.
- Applying subject knowledge to create something.

Communication

- Explaining a subject or topic to someone else.
- Describing what can be done with acquired knowledge or skill.
- Directing someone else to complete a task.
- Asking questions to acquire knowledge or skill.

Computing

- Searching for relevant content from the Internet.
- Detecting different points of view.
- Detecting bias, misinformation or doctrine.

- Using appropriate technology to solve a problem.
- Understanding advertisements, marketing hyperbole and lies.

This list can be modified, expanded, reorganised, etc. However, as long as we have a measure of the three Cs, comprehension, communication and computing, we would know how our learning process is progressing.

There are tests to measure comprehension, communication and computing. I think they are useful to some extent.

At the pinnacle of our education system is the Ph.D. It is an attempt by a learner to answer a question (or questions) to which no one knows the answer. Any method is allowed – all sources of information, discussion, intuition, analysis. A Ph.D is a SOLE.

While all other titles and degrees are awarded largely on the basis of examinations, the Ph.D is not. A Ph.D is awarded on the basis of written communication, a thesis. The worth of a thesis is judged through a conversation between the candidate and a couple of experts, to gauge the candidate's comprehension of their own thesis. Finally, the experts also gauge if the solution proposed by the candidate was arrived at using acceptable methods. In other words, the Ph.D is granted on the basis of a subjective evaluation of comprehension, communication and computing.

If the highest degree granted by the educational system is based on a SOLE and a measure of comprehension, communication and computing, it would be reasonable to apply similar methods to other levels of education. It would be expensive and time consuming, but it can be done.

Once you have measured learners' capabilities using this method above instead of nerve-wracking tests of memory, you need to certify so that others can have a basis for understanding a learner.

Certification

If the objective of education is to enable learners to live happy, healthy and useful lives, then certification should be a record of how far these objectives have been achieved. We need a certificate that tells us about:

Happiness

- Focus, facial expression
- Fear and fidgeting
- Humor, smiles, laughter

Health

- Height, weight, BMI
- Medical history
- Sports performance

Usefulness

- Knowledge and skills
- Learning, problem solving and creative ability
- Comprehension, communication and computing
- Behavior, manners and empathy

Some of these parameters can be measured with numbers, but most would be evaluated by teachers using a 'Ph.D - like' method. I would trust the judgement of a trained teacher who has worked with a child for a year or more, just as an enlightened employer goes by reference letters from people who know a candidate, more than a numerical score.

There would have to be checks and balances within the system to ensure that subjective methods are used correctly – these need to be worked out by individual institutions.

The certificate should fit on a normal-sized page, it would be an invaluable guide to understanding a learner.

Schools and Homes

Education systems cannot be changed overnight. Neither can schools or homes in the post-pandemic world. The changes need to be made brick by brick and not by demolition and reconstruction.

Physical schools must remain where they are and look the same. Only the number of children coming in at any time will be a lot smaller than before. Inside the school, a space allocated for virtual attendance will enable children to 'beam in' from home. So will many teachers. The virtual component of a school will enroll children and teachers from all over the world. School will be open 24 x 7.

Each child will attend school, either physically or over the Internet, for about four hours a day. 'Classes' will have four children and a teacher and last for 90 minutes. The reasons for these numbers are in the discussion above.

At home, a space needs to be allocated for remote schooling. A square of about fiur feet to each side should be enough, if you can afford it. Try to match Heppell's conditions (above) as closely as you can. The space should contain a computer with a camera and speakers. Here are some tips:

The screen: This should be big enough so that faces can appear life size. A computer screen of about 20 inches diagonal is the minimum that will do this. A smart TV will work even better. The person whose face you are looking at should hold up a foot/metre scale next to their face. On your side, take a similar scale and put it against the one in the image. If the two matches, you've got life size. If you do not have a scale, use a standard bottle or something. In a school, you could use a projected screen if two classes are interacting. Get the image to be life size, using the method described above. If you are projecting using a traditional projector, people's heads will come in the way. Use a 'very short throw' projector. These are so close to the screen that you can't come in the way. They are a bit expensive, though.

Audio: Use HiFi speakers. Bluetooth speakers are getting better all the time. Use microphones that are tiny and invisible. Don't use headphones, they make you look as though you are speaking from the International Space Station. If you have to, use earbuds.

Camera: This is tricky. Most cameras are unobtrusive, but they are usually on top of the screen. So, the person you are talking to appears to be looking over the top of your head. This can't be helped, but you can reduce the problem by looking at the camera instead of at the image of the face on the screen. To the other person, you will then look as though you are looking directly at them. It takes a bit of getting used to. If you are using a projected screen, you can try to fix a tiny camera in the centre of the screen. This will solve the problem.

Don't wear clothes with checks or stripes, they produce what are called 'jitters' on the other screen.

Maybe you will get some of the vibe of a real conversation back into cyberspace!

Timing for sessions out of home can be tricky, it depends on what time zone the school you are connecting to is in. You are not used to this kind of school and neither is your child or children. If there are children of different ages, they may need separate spaces or time slots in the learning space. It can get confusing, but you will figure it out.

Learning – in the times to come will happen with relationships, trust, encouragement and freedom.

There may not be any other way.

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