Studio School: Robotic Professors, Games, Simulations, Virtual Labs, and the Future of Education

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ABSTRACT

This article makes an analysis based on Kondratieff Cycles, investments in Research and Development (R&D,) and major trends in the future of work and education, to propose a new educational model termed 'Studio School, which is necessary to cope with those new technologies, and future needs of the society.

The global pandemic was an accelerator in those trends, and exposed the obsolescence of the current model.

This new model is mainly remote, and will require a strong support from experiential methods and techniques to work. Therefore, remote lectures, robotic professors, games, simulations, and virtual laboratories will be necessary.

Differentiation between school for inter-school competition will be done foremostly by the creation of exclusive content in form of research, and events (physical and virtual).

This new model is a blend of movie, television and game studio, which can work under a few different business models like subscription, pay-per-use, marketplace and syndication.

This new model is far from complete and will evolve during the next few decades.

INTRODUCTION

The COVID-19 crisis accelerated many long-term trends in technology adoption, forcing a strong growth of the remote education. This exposed how much the current education model was lagging behind in terms of demand, and technological possibilities.

This article introduces an analysis based on Kondratieff Cycles, investments in Research and development (R&D), and of the major trends in work and education, and then proposes a new model for future education, that is , studio schools, which would incorporate several experiential techniques in remote education to gain scale and make possible for millions of students to have high quality and affordable education.

KONDRATIEFF CYCLES

Nikolai Kondratieff (1892-1938) was a Russian mathematician that lived in early 20th century. In the 1920's the soviet regime asked him to create a model that could prove that capitalism would fail and communism would prevail. Kondratieff then studied the economic history and concluded that the 'class struggle' variable explained very little, and that the best variable to explain economic growth was 'technology'.

He started analyzing the logic of the first and second industrial revolutions, but soon concluded that there was more than that. Every 50-60 years there was a great technological revolution and that occurred around 20-30 years after a great systemic crisis. Because of the crisis period people had invested in new technologies by "thinking out of the box", accepting new risks, and trying new things (Kondratieff, 1935).

That reminded what Marx (1991) had predicted, that is, that Capitalism was unstable and would create crisis for itself, but unlike Marx's predictions it wasn't 'class struggle' the driving force of change, but rather 'technology'. Also, capitalism didn't "end", it "reinvented" itself.

The Kondratieff Cycles have evolved since their initial description and tested. Spectral analysis confirmed its existence (Ewijk, 1982). The biggest discrepancy in the cycles is found in the "long Depression" (1873-1896).

There are a few different descriptions on their timeline depending on when the cycles are considered to start. It's considered that we are at the end of the fifth cycle, and that they start around the 1770's, but Modelski (2005) consider that we are in the 19th cycle, and that they started in the year 930 AD. However, statistics as we known appeared in the 1740's, so it's safer to model those

cycles after this period when data is more reliable and abundant, so the 5-cycles model is more sound.

Table 1 shows an interpretation based not only in the technological revolutions, but also based on the military and social crisis that close each cycle, which are show on table 2. Those tables include the forecasted 6th cycle between 2030 and 2080.

TABLE 1
Kondratieff Cycles

Cycle	Period	Description
1st Cycle	1770-1820	Initial Mechanization
2nd Cycle	1820-1870	Steam, Telegraph and railroads
3rd Cycle	1870-1930	Electricity, internal combustion and heavy engineering
4th Cycle	1930-1980	Mass production, Fordism, Nuclear power, television
5th Cycle	1980-2030	Telecommunications and Informatics
6th Cycle	2030-2080?	?

Source: adapted from Freeman e Perez (1988)

TABLE 2
Crisis Sub-phase of the cycles

Cycle	Period	Description
Pre-cycles	1755-1770	Seven year's war (1756-63)
1st Cycle	1805-1820	Napoleonic wars
2nd Cycle	1860-1870	Crimean War, American Civil-War, Triple alliance War, Unification of Germany and Italy
3rd Cycle	1914-1930	First and Second World wars and inter-war period
4th Cycle	1965-1980	Vietnam war, Space race, Arab Israeli wars (1967, 1973)
5th Cycle	2015-2030	?
6th Cycle	2065-2080?	?

Source: Alves, 2018

The term "industry 4.0" that became famous recently has a lot of connection with the Kondratieff cycles, since it refers to "waves" of technological revolutions. The "industry 1.0" corresponds to the first two cycles, "industry 2.0" would be the equivalent to the third and fourth cycles, "industry 3.0" relates to the fifth cycle. The sixth hypothetical cycle would be "industry 4.0".

INVESTMENT IN RESEARCH AND DEVELOPMENT (R&D)

The Kondratieff model predicts that the period of 2015 to 2030 will see a major set of investments in Research and development (R&D) in order to overcome a series of crisis. That will transform Capitalism from one format, into a new one. In that sense it's possible to look and the R&D budgets around the world and "follow the money" in order to try to understand where money is being invested, and with which purpose.

The main source is the R&D Magazine Global R&D funding forecast (R&D Magazine, 2017; R&D Magazine, 2018; R&D Magazine, 2019), which compiles information from several sources. Looking at that body of data it's possible to see five major axes of investment:

1. Space technology,
2. Renewable energy sources,
3. Automation (industry 4.0),
4. Digital transformation (DT), and
5. Human enhancement (HET).

Actually the reason behind those five axes is the desire from USA to bring back manufacturing to its own territory. Since the 2008 crisis the professional bureaucracy, formed mainly by the Department of Defense (DoD), Department of Energy (DoE), and Department of Commerce (DoC); decided that it was time to shift the industrial center of the world from Asia to where it was moved in the 1960-1990 period (a process known as "offshoring"), back to the USA (a process branded as "reshoring").

But since a Chinese worker has an average wage around one-fifth of the average American worker, and an Indian worker has around one-tenth of this wage, it was only possible to "reshore", or "bring back manufacture" by compensating higher wages with higher productivity, and lower costs in terms of energy and materials.

The first two axes (Space and energy) are concerned with reducing the costs of energy and materials. Energy costs have reduced significantly in the recent years due to the widespread of solar cells and a new generation of batteries. Since 2018 it has been relatively frequent to have negative energy prices during the day in the USA, Europe and Australia (Bloomberg, 2018). That means that the energy matrix will see a major rebalancing in the near future. While that access to the space has seen a dramatic reduction in cost due to the development of reusable rockets by Space X, and other companies like Blue Origin, and ULA are also developing rockets with this technology. Space Mining will probably become practical, and economically feasible in the 2020's.

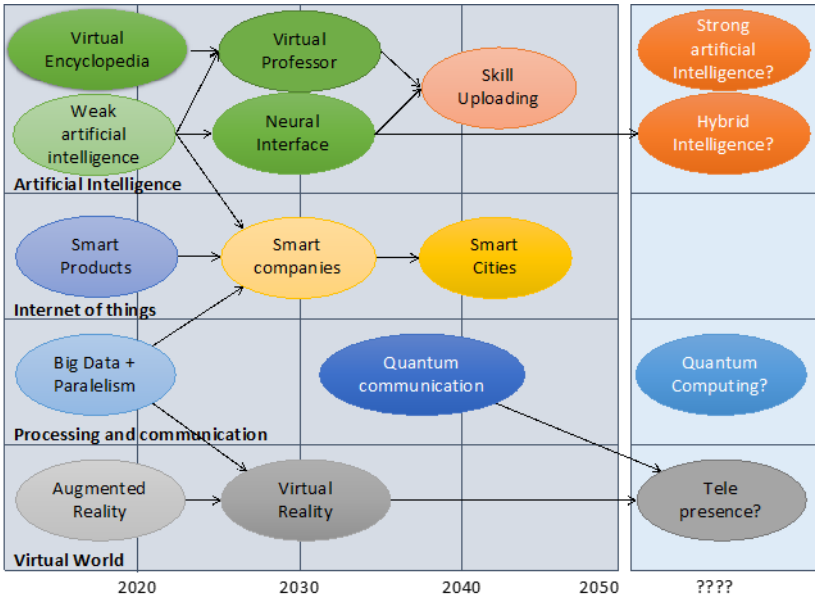
The third and fourth axes (Automation and Digital) will reduce the need for unskilled human labour, while increasing the need for more skilled human labour. Schumpeter (2007) described this process as "creative destruction", that is, millions of jobs will be destroyed, and whole industries will disappear, but at the same time millions of new jobs will be created and new industries will appear. The future of work has been a subject of discussion recently in some sources (Alves, 2015; WEF, 2018). However, the reduction in labour costs just one side of this change, the increase in productivity with 3D printers, exoskeletons, collaborative robots (Cobots) artificial intelligence (AI), autonomous vehicles, drones, internet-of-things (IoT), Big data, facial recognition, and virtual reality (VR) is still to be fully determined. The terms Digital Transformation (DT) and Industry 4.0 have been coined to summarize the changes in production chains by those technologies.

The fifth and last axis (HET) will increase the lifespan and the quality of life making intellectual capital even more productive, while reducing the cost of maintaining a labour force. This will change how health systems in general work, and force existing pension funds system to be reinvented. We can divide broadly those technologies into three lines: curing diseases, increasing lifespan, and human enhancement/alteration. All those three lines pose opportunities and challenges for the public administration, private sector, and society, but in general health systems will change from "curing" existing health problems, to "regenerating and upgrading" health conditions. From the perspective of the public administration and private sector it will be interesting, since it will be cheaper to maintain a healthy population that will live and work longer, and therefore pay taxes for a longer period. Investment in intellectual capital will have a longer time to pay itself, so it will become even more attractive to invest in life-long education. Although its arguable how much the life expectancy in the population can increase, reaching for 100 to 120 years of life expectancy is very likely.

THE FUTURE OF WORK

This major change in the technological possibilities has been forcing many organizations and authors to consider how the future of work will be like the Institute for the future (2011), WEF (2018), and Alves (2015, and 2018).

FIGURE 1
Roadmap for Digital transformation



Source: Adapted from Alves, 2018

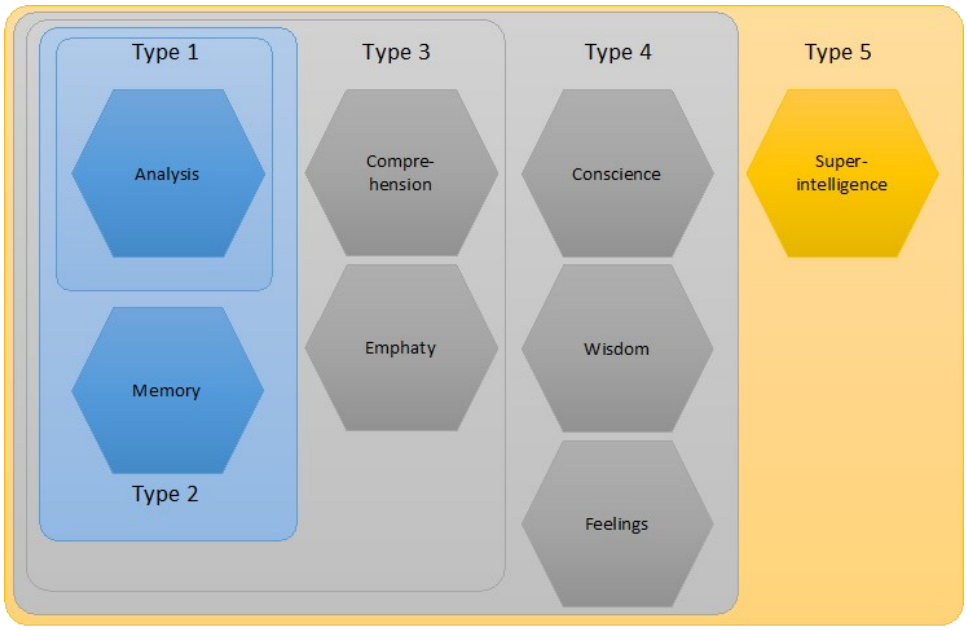
It's possible to identify three main three long range trends in the future of work: extreme robotization, extreme longevity, and extreme dispersion (Alves, 2015 and 2018).

Extreme robotization Refers to the third and fourth axis described previously. Figure 1 shows a roadmap on how those technologies will unfolds in four distinct pathways: artificial intelligence (AI), Internet of things (IoT), Processing & communication, and "Virtual World".

The solid lines indicate "technological precedence", that is, one technology makes the next feasible. In the X axis we find the timeline, but the last column, forecasted in the 2050's constitutes a series of doubts due to technological barriers, but also due to legal, cultural and ethical barriers.

What exists today in artificial intelligence is a series of algorithms that mimic human thinking. This is denominated Weak AI, and is distinguished from Strong AI. The main difference between those is show in Figure 2, this classification is not unique, nor necessarily the best possible, it's just useful for educational purposes. Types 1 and 2 are weak AI's, Types 3 and 4 are Strong AI's, and Type 5 is a superintelligence. Currently we don't have a theory of mind "good enough" to create a Strong AI, or a superintelligence.

FIGURE 2
Types of Artificial Intelligence



Source: Alves, 2018

Extreme longevity refers to the fifth axis previously described and implies several changes in cultural, political and economic dimensions. Figure 3 shows a simplified causal network of those consequences. This causal network is designed based in the more conservative hypothesis that longevity will be extended to 120 years within one generation. An older and healthier society will work until a later age, and therefore the preparation for the life will also take longer. Family developing strategy will also change with maternity being later in life to allow for better preparation. Intellectual capital will therefore last longer in terms of productivity and investment in education through life-long learning will be an better investment of time and money.

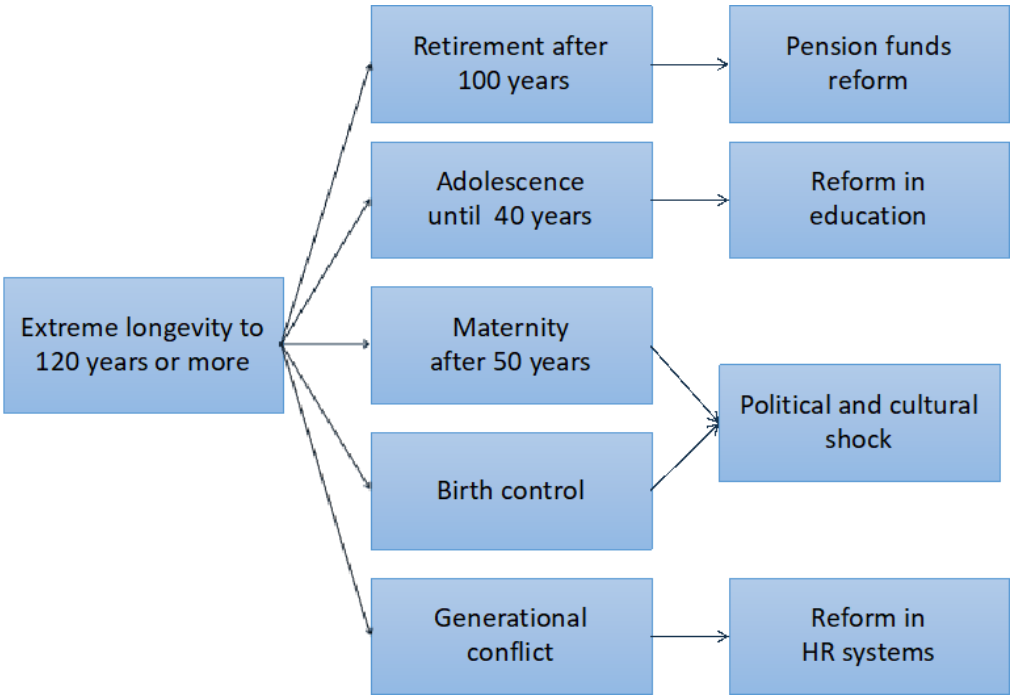
Human resources and pension funds systems as well as education will have to be reformed to adjust to this new reality.

Extreme dispersion refers to the first, second and fourth axis previously described. Organizations have been spreading geographically faster since the introduction of telecommunications with the telegraph in the second Kondratieff Cycle, but that gained speed with the revolution in telematics associated with the fifth Kondratieff cycle.

In the next decades the new space race will allow organizations to be spread not only across the Earth, but also in the Earth-Moon system, and possibly with the advent of Space Mining up to the main asteroid belt. Part of this dispersion may be possible due to the advancement of Digital Transformation (DT).

Such a dispersion is making remote work more common, inducing a change from the traditional office to a rotation office and from big office towers to smaller offices better dispersed geographically. Figure 4 shows the dispersed work model. The cloud system is the best developed part of this triad. Home offices are still inefficient or improvised in most cases and will have to become

FIGURE 3
Effects of extreme longevity



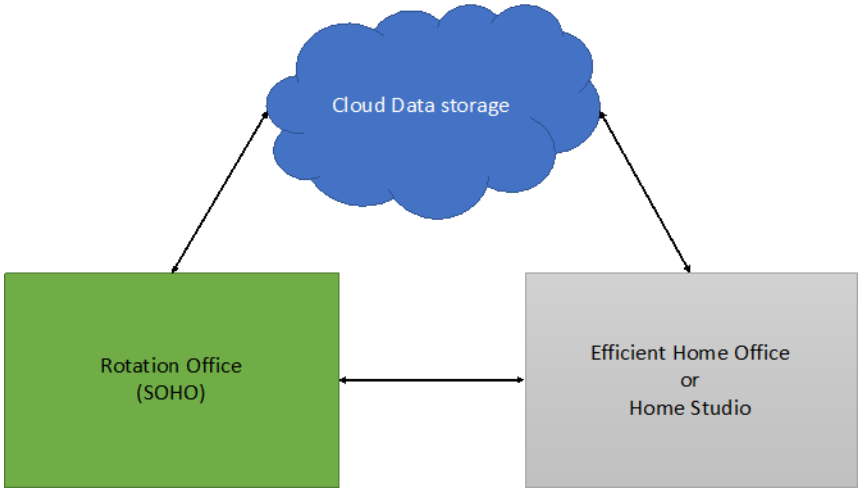
Source: Alves, 2015

better developed in the next decade or so. The same is true for SOHO rotation offices. Currently most organization still try to make a headquarters that concentrates their activities. This is very inefficient in terms of traffic organization in cities, talent acquisition, and headquarters costs to build and operate. Also some jobs could be relocated to offshore or "near shore", not only to facilitate contracts, but also to allow a better workflow over the time zones, allowing projects and processes never to stop.

One important aspect of this change is that we will see "creative destruction" of jobs as described by Schumpeter (2007). Millions of jobs will be destroyed, but more jobs will be created due to reduction in costs, and price elasticity.

To better explain that phenomenon let's examine a hypothetical example. Let's assume that a certain product or service is done with four employees at a cost of $1,000 per unit. A new technology appears and now the same product or service can be done with just one employee at a cost of $100, that is, not only the labor cost reduced but other costs also lowered. Initially the number of jobs was cut from four to one, however since the cost is now lower, for the same economical cost for the society we can now consume ten units, and therefore employ ten people. In the end the number of jobs increased from four to ten. But it's important to

FIGURE 4
The dispersed wok model



Source: Author

make it explicit that this "magic" only occurs if there is a price elasticity, that is, if a lower price will imply in a higher demand.

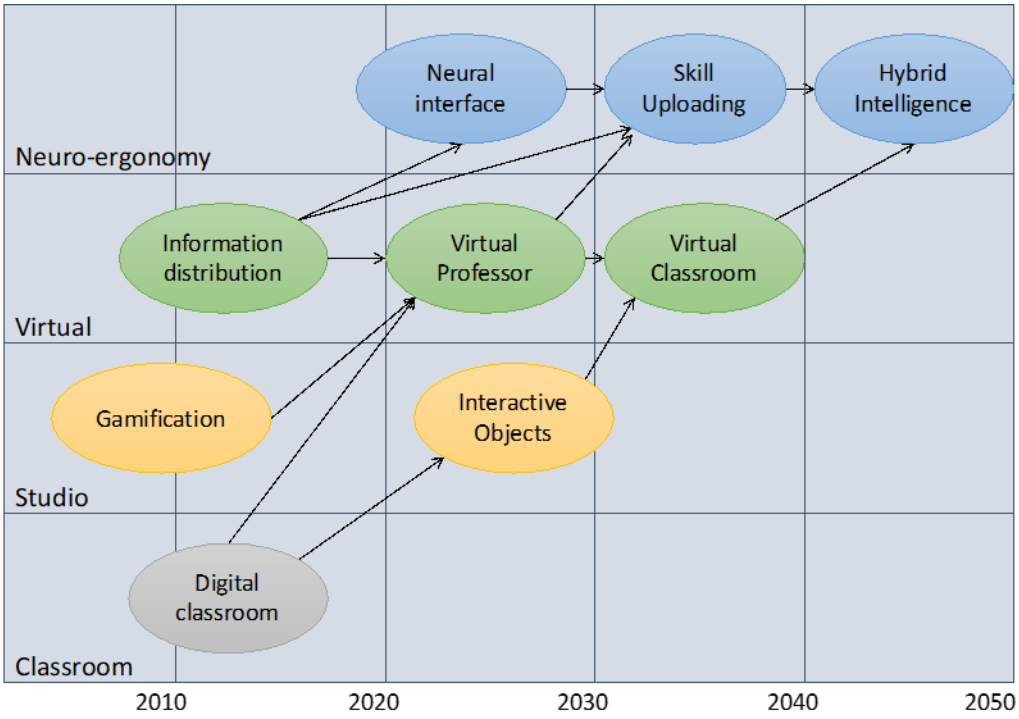
Another important consideration is that along the last 250 years, or five Kondratieff cycles, some technologies were considered 'enabling', that is, they destroyed some jobs, but they enabled new things to exist, not only following the mechanism described above, but also creating completely new industries. Electricity in the third Kondratieff cycle is possibly the best example, since lots of today's machinery and equipment runs on electricity and would not be possible without it. Electricity eventually led to electronics which is another crucial enabling technology allowing all the current telematics revolution. Now we are approaching a new set of enabling technologies jointly described as Digital Transformation (DT), but in particular Artificial Intelligence (AI) and Internet of Things (IoT).

The compound effect is that the future will not see a lack of jobs, but rather a lack of education and developed competencies in the work force. In this sense next step to better understand the future of Education and how a new model of school can be better appropriate for such a task.

THE FUTURE OF EDUCATION

All those changes have prompted some organizations and authors to think about the future of education like the US Department of Labor (Envisioning, 2012) and Alves (2015, and 2018). Figure 5 shows a roadmap based in those two sources. The bottom three lines are from the study made by the US Department of Labor in 2011, and the top tier is this author addition due to the development of Neuro-ergonomy, that is, Brain Computer interfaces (BCI) which are reaching the stage of technical feasibility and may attain economic feasibility status within one decade.

FIGURE 5
The future of education roadmap



Source: Alves, 2018

It becomes clear by this roadmap that the school is becoming not only remote, but also becoming closer to an Studio, whether a television, movie, or game studio. This will allow education to become cheaper and more accessible.

Nowadays the limiting factor for schools are finding good professors and building facilities. It's possible to build good school for one thousand students, but not for one million students. However with remote education, robotic learning, and eventually hybrid intelligence it will be possible. This means a lower cost to educate the population will also meet a longer work life, so this knowledge will pay off even better for both the individual, the parents, and the society.

Current distance learning is not very efficient compared due to lack of engagement, more specificaly the Learning Management systems (LMS's) are used as a repository of files like videos, texts, and slides.

A future school model will have to include more games and virtual laboratories to engage through experiential learning. That means we not only will have exceptional content, but it will also be exceptionally engaging. In fact experiential learning is the key to the future of education.

THE PANDEMIC ACCELERATOR

In 2020 the COVID-19 pandemic created a crisis that forced out of the box thinking. Just like the Kondratieff Cycles predict "desperate times require desperate measures". A global pandemic was among the list of possible triggers of such a crisis (Alves, 2018). We had at least five major pandemics in the last decades, more specifically, AIDS, Ebola, SARS, MERS, and H1N1. In the future new pandemics will occur, but it's impossible to forecast when, on a very broad 'rule of thumb" we can expect at least one per decade.

This induced what has been described as a "low touch economy" which broken four resistances: Online-shopping, home office, remote education, and telemedicine.

Those "trends" were deemed to change work and education in ten years, but this was forced by the crisis to occur in less than one year. This exposed how inappropriate the current educational model is how much resistance to new already established technologies existed.

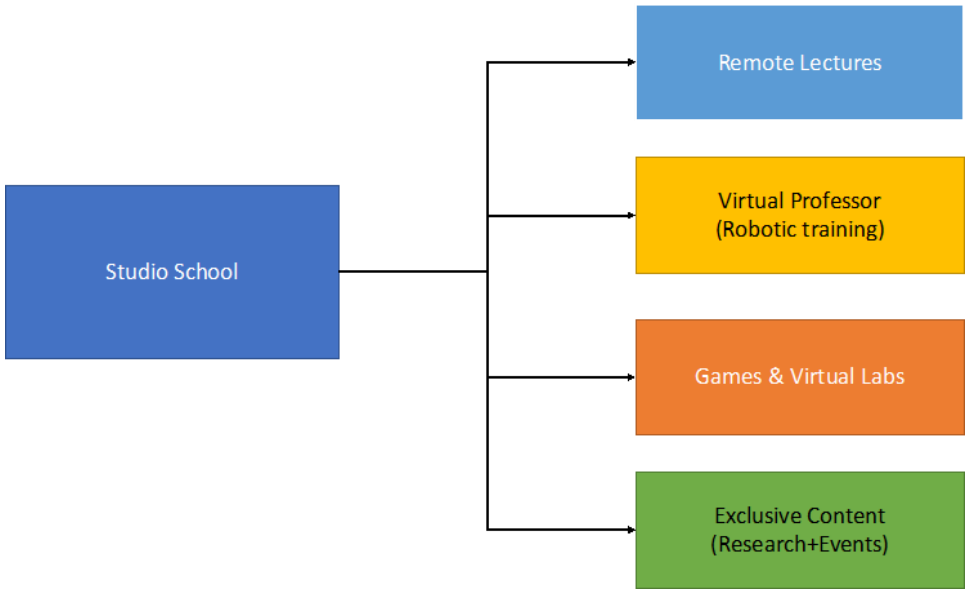
Exactly as the Kondratieff cycles predict, is a major crisis that is precipitating the change.

THE STUDIO SCHOOL

This article suggests that the new model to be capable to deal with not only the current crisis, but to incorporate the future technologies, as well as being able to distribute high quality education for a large population, is a studio school.

Figure 6 shows the main components of what is the studio school model, basically a blend of school, television, movie and game studio.

FIGURE 6
Studio School



Source: Author

The Studio School model will only be possible if content can be delivered on the distance, and therefore it relies strongly on experiential learning, mostly in the form of videos, games, simulations and virtual laboratories. Also remote interaction between the students and the faculty will be done on several platforms, not only the LMS.

Most classes would be remote, either synchronous or asynchronous. Some of them would be delivered by artificial intelligences (AI), or robotic professors, that would be able to detect the gaps in knowledge and skill of the student and recommend further reading, videos, games, virtual labs, virtual exhibitions, exercises, cases, interactive cases, and real-world practices.

The need for learn by doing, would be delivered by a strong suite of games, simulations, cases, interactive cases, and virtual

labs. This would more than compensate the lack of presential interaction as it can be done in in groups or individually, as well as in the students own pace or by schedule.

The differentiation and positioning in terms of inter school competition will be done by exclusive content which can be not only better robotic professor, games, simulations, and virtual labs, but also through research focus, and physical and virtual events.

This model however is better fit for secondary education (6^{th}-12^{th} grade), higher education (under graduation), post-graduation (master and doctoral degrees), and lifelong learning (extension courses and executive education). For the primary education (K-5^{th} grade) the traditional school format will still be needed and the studio school will see limited usage.

The Studio School being a new strategy will require a new structure, not only in terms of physical structure, but also organizational structure, and business model.

The large campi structure that many schools have around the world was a major asset in delivering and attracting students in the current model of education, but now they're a large fixed cost. These structures can be sold in order to create cash, reduce costs, and allow for investing in new structures.

The reduction in costs to deliver education will likely allow for growth in demand creating a "creative destruction" wave that will generate more jobs in the education sector than it will destroy. But a new set of professionals will be needed in order to program AI's, create content (games, virtual labs, virtual exhibitions, videos, cases, and lectures), mentor students, and deliver remote lectures. A new mix of competences will be need for the educational workforce.

This content may be distributed using, and combining, a few different business models like subscription, marketplace, pay per use, and syndication. It's still unclear which of those business models will prevail.

Well known schools with strong brands will probably prefer a subscription model, while creating a marketplace. Lesser known brands will probably need to start with a pay-per use model, some examples are Udemy and Educera.

Currently we can see an ecosystem developing with business games providers (Capsim, Forio and Markstrat for example), remote lecture tools (Zoom, MS Teams, and Webex for example), learning management systems (Blackboard and Canvas for example), robotic trainers, virtual reality tools (Merge Cube for example), content providers (Pearson education for example), educational marketplaces (Amazon education for example), and virtual encyclopedias (Wikipedia for example). This ecosystem will evolve and grow reducing the barrier of entry in the educational market, and also reducing the costs of internationalization.

In many ways educational content delivery is similar entertainment content delivery. This means educational industry must study what happened in the movie and television industry which have evolved from limited offers (in terms of time, location or channel), into streaming, which is a subscription model with user controlled usage. This means that exclusive content, also known as original content, will be key to maintaining a loyal audience.

Original content can be done by research, but also by creating very engaging games, virtual labs, virtual exhibitions, videos, cases, interactive cases, and experience. It becomes clear that experiential learning takes a central position in this model.

Finally as the frontier between industries becomes less clear, and synergy increases, it's possible to occur a series of Mergers and acquisitions (M&A), like happened in the last decades between movie, television, publishing and internet industries. This means that acquisition of some well-known brands in education may be seen in the future.

CONCLUSIONS

This article has reviewed how the Kondratieff Cycles explain the current crisis and technological revolution, and how it will lead into a strong shift on how education is delivered to the population in general.

By forecasting the trends in work and education, it becomes clear that a new school model, is necessary. The global pandemic of COVID -19 exposed the obsolescense of the current model, and accelerated the process of change.

This new model is suggested to be termed 'Studio School'. and will need to be strongly anchored in experiential learning due to its remote nature, and therefore will need to include robotic professor, games, simulations, and virtual laboratories. Differentiation between school due to inter school competition will be done by creating exclusive context in several ways, but foremostly through research and events.

This new Studio School model is far from complete and will evolve in the next few decades.

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