NIE
NATIONAL INSTITUTE OF EDUCATION
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# The Future of Learning

CJ Koh Professorial Lecture Series No. 10
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The Future of Learning
*CJ Koh Professorial Lecture Series* No. 10
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# FOREWORD BY SERIES EDITOR

## ASSOCIATE PROFESSOR CHANG CHEW HUNG

**ON BEHALF OF** the CJ Koh Professorship secretariat and the publication team, it is my pleasure to present to you the 10th issue of the *CJ Koh Professorial Lecture* Series—"The Future of Learning". This is a consolidated report of the National Institute of Education (NIE) Faculty and Students Seminar and the Professorial Public Lecture delivered by Professor George Siemens, who was appointed the 14th CJ Koh Professor from 7 to 18 October 2019. The main objective of this report is to ensure that the rich and insightful discussions arising from Professor Siemen's appointment reach out to key stakeholders within NIE, Singapore's Ministry of Education (MOE), and the wider local and global educational fraternity.

The CJ Koh Professorship has been made possible through the generous donation of S$1.5 million to the Nanyang Technological University Endowment Fund by the late Mr Ong Tiong Tat, executor of the late lawyer Mr Koh Choon Joo's (CJ Koh) estate.

In the Seminar entitled "The future of digital learning: What technology can and cannot do" held at NIE, Professor Siemens discussed the developments in the use of technology for learning and the need for a transition in learning. In the Public Lecture titled "The Future of Learning: The Potential of Artificial Intelligence for Education", held at The Lifelong Learning Institute, Professor Siemens outlined the developments of Artificial Intelligence, paying particular attention to human cognition, especially with wider adoption of Artificial Intelligence in education.

In this report, we have also included a summary of AI in Education related studies conducted by NIE faculty. This will provide some context for the work that had been done locally as well as encourage the reader to reflect on the issues raised by both local and international scholars on a topic that is becoming increasingly relevant to our work in education.

I would like to take this opportunity to thank all who have contributed to this report in one way or another. Special thanks go to our NIE Director Professor Christine Goh for her support of the *CJ Koh Professorial Lecture Series* and to Professor George Siemens for sharing valuable insights with us during his appointment as the 14th CJ Koh Professor.

This consolidated report would not have been possible without the excellent secretariat support from Ms Adeline Seow and the publications team which supported the writing from the first drafts to the final product. In this respect, our thanks go to (in alphabetical order) Dr Dennis Kwek, Ms Nur Haryanti Binti Sazali, Ms Ow Ming Li Phoebe, Mr Shyam Anand Singh and also to our wonderful colleagues from the Office of Education Research (Research Engagement & Publications Unit) for their typesetting, copyediting and careful proofreading work.

We present to you the tenth issue of the *CJ Koh Professorial Lecture Series*— "The Future of Learning".

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**Nanyang Technological University, Singapore**
**March 2021**
**Singapore**

# PREFACE BY NIE DIRECTOR

## PROFESSOR CHRISTINE GOH

**2020 WAS A** significant year for Singapore and for NIE. Two months after Professor George Siemens, the 14th CJ Koh Professor, visited Singapore, news trickled in of a highly virulent and deadly Severe Acute Respiratory Syndrome Coronavirus. The COVID-19 pandemic rapidly became the most challenging crisis the world has faced for almost a century. Not only has it disrupted life as we know it, it has closed national borders, curtailed international travel, shrunk economies, overturned education systems, and created significant hardships for many people around the world. Fortunately for Singapore, the government's decisive policy responses and robust public infrastructure have helped to limit the damage that the global pandemic could have had on Singapore.

A key consequence of the pandemic at the beginning had been the uncertainties around schooling and education more broadly. The government and universities were quick to transform ways of teaching and learning, and to seize the transformative opportunities to bolster blended learning. The acceleration of the adoption of digital technologies and the use of technologies to ensure that students have minimal disruptions to their learning have been two important changes to our education landscape. It is in this context that Professor Siemens' work matters even more so now.

Professor George Siemens is internationally respected and well-known for his deep understanding and knowledge of how to make higher education thrive in the digital age. His research work focuses on networks, analytics, and human and artificial cognition in education. Cognisant that current learning theories driven by behaviourism, cognitivism and constructivism were developed in a time when learning had not been impacted by technology, Professor Siemens developed a learning theory reflective of the pervasiveness of technologies in our modern age, and of the need to make connections not only at the neurological or conceptual levels, but importantly, through external human, and digital, systems. His learning theory—"Connectivism"—provides a new perspective on how Internet technologies are creating new opportunities for people to learn and share information online and among themselves.

As the CJ Koh Professor, Professor Siemens presented his leading-edge thoughts on the future of learning, the potential of Artificial Intelligence (AI) for education, and how digital technologies can not only impact the human condition, but create new learning opportunities for schools and universities. He encouraged us to consider foundational issues that will drive formal education, such as how the traditional roles of schools and universities will be affected by online learning, what kinds of changes are needed to ensure the future of education, and examining the growing influence of data and analytics to education and educational practices. His research work is poignant in the COVID-19 period given the digital accelerations being experienced in all aspects of formal education. In particular, Professor Siemens' research into AI suggest to us that rather than displacing humans, artificial cognition is encouraging us to embrace the idea of "beingness"—to cultivate attributes that make us human, such as emotions, affect, kindness, compassion. Additionally, his research into networks bring to mind how NIE continues to

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step up networking partnerships and collaborations with both MOE and NTU to implement significant new initiatives in 2020, such as the SkillsFuture for Educators professional development framework and roadmap for Singapore school teachers, and the NTU MiniMasters Programme which creates opportunities for individuals to commit to lifelong learning and adapt to changing economic aspirations and needs.

Professor Siemens' contributions to knowledge is timely. In January 2021, the Nanyang Technological University (NTU) had launched their strategic plan for the next five years. Termed NTU2025, the university seeks to address a number of humanity's grand challenges, two of which are relevant to Professor Siemens' and NIE's work collectively: (1) To harness the science, art and technology of learning; and (2) to address technology's impact on humanity. The first seeks to prepare universities and schools to equip learners of the 21st century, drawing on approaches to the science, art and technology of learning. Here, we see Professor Siemens' idea of Connectivism and his research into AI and learning analytics playing fundamental roles in advancing knowledge around teaching and learning. The second grand challenge examines technology and its relationship with humanity and society, and Professor Siemens' point about the increasing importance of sense-making and meaning-making in the Post-Learning Age will undoubtedly drive deep discussions on what role education will need to play to help humanity navigate the rapid technological advances that will undoubtedly impact lives, cultures, societies and economies.

**Professor Christine Goh**
**Director, National Institute of Education, Singapore**
**Nanyang Technological University, Singapore**
**March 2021**
**Singapore**

# ABOUT THE CJ KOH PROFESSOR GEORGE SIEMENS

**PROFESSOR GEORGE SIEMENS** is an eminent scholar on technology, networks, analytics, and how human and artificial cognition impact knowledge development and society. Professor Siemens is Professor of Psychology at University of Texas Arlington. He leads the development of the Center for Change and Complexity in Learning (C3L) at University of South Australia. He has delivered keynote addresses in more than 35 countries on the influence of technology and media on education, organizations, and society. His work has been profiled in provincial, national, and international newspapers (including NY Times), radio, and television. He has served as Principal Investigator (PI) or Co-PI on grants funded by National Science Foundation, Social Sciences and Humanities Research Council (Canada), Intel, Boeing, Bill & Melinda Gates Foundation, and the Soros Foundation. Dr Siemens is the founding President of the Society for Learning Analytics

Professor Siemens is a writer, theorist, speaker and researcher on learning, networks, technology, analytics and visualisation, openness, and organisational effectiveness in digital environments. He is the originator of Connectivism theory and author of the article “Connectivism: A Learning Theory for the Digital Age and the book Knowing Knowledge”—an exploration of the impact of the changed context and characteristics of knowledge. Professor Siemens has received honorary doctorates from the Universidad de San Martin de Porres (May 2012) and the University of the Fraser Valley (June 2014).

# THE FUTURE OF DIGITAL LEARNING
# WHAT TECHNOLOGY CAN AND CANNOT DO

**PROFESSOR GEORGE SIEMENS**

**14 OCTOBER 2019, SEMINAR, NIE, SINGAPORE**

**Synopsis**

**IN THIS SEMINAR,** Professor George Siemens explores how digital technologies impact the human condition. How do technologies influence the development of "human skills" such as self-regulated learning, creativity and collaboration? What is the longer-term impact of the explosion of learning opportunities—massive open online course (MOOCs), open education, YouTube—on the role that is traditionally played by universities? How will educators ensure an educated populace with coherent structures of knowledge reflective of modern science will enter the workforce and society after graduation? The following is a transcript of the seminar.

**Introduction**

One of the things I have spent many years looking at is: How do digital technologies influence and impact how we live? I was born in a little city called Cuauhtémoc in the province of Chihuahua in Mexico and was raised in a farming community with a non-technological belief system which meant that technology was lack for a better word, forbidden. Something as basic as tractors, for example, would not be approved by the religious order. When I was six or seven years old and moved to Canada, one of the first things I discovered in the school system was that there was a prevalence of things that I did not experience when I was growing up in Cuauhtémoc. I was introduced to the Commodore PET computer which was significant because of what it meant—how we could interact with information and how the ability for individuals to be creative with technology was already present in those early experiences.

Over time, my interest with technology remained high. I started programming and bought my first IBM laptop with a 40-megabyte hard drive. There was something about this device that altered information availability

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even with early stage gopher or early attempts at web browsing when Mozilla and other browsers started to become an option. It indicated to me that there was something about technology that was worth a sustained exploration.

In some ways, I believe that my past interactions with technology is reflective of how technology has been used within the education sector. In the following sections, I will provide a brief account of this historical timeline in stages. I posit that the technological tools that we have access to shape our potential with information—in some cases, it gives us more power, influence and ability; in other instances, it diminishes our control and takes away our autonomy.

**Pre-Web Era**

One of the first lessons of the digital age is that digital content is not a key value point. In the late 1990s, while the web was in the early stages of development, the corporate learning space heavily subscribed to computer-based training (CBT). Internet connection was yet to be widely available during this time. To facilitate learning, Microsoft developed a digital encyclopedia called *Encarta* as an information tool for its users. Early feedback from focus groups conducted by Microsoft listed the estimated value of Encarta to be worth thousands of dollars. However, when Encarta eventually declined in use due to a range of new innovations such as *Wikipedia*, it was selling for USD$19.95. This example demonstrates that digital content is not a key value point in the digital age because content can be easily reproduced without any perceptible increase in cost.

The mindset, during the early stages of CBT, focused on content. Laser discs and DVDs were some of the main tools used to disseminate educational content. Unfortunately, these innovations were self-contained as it lacked a global reach. Nevertheless, it was an early indication of what might come with the development of web technologies.

One of the functions of new technology is its transformative impact on human lives. The rise of *WebCT*—an online proprietary virtual learning environment—across colleges and other learning institutions, was transformative in that not only did it allow for instructors and educators to upload course content on to a digital platform, it provided for student interaction and peer learning through tools such as discussion boards, mail systems and live chats. This trend of student interaction and peer learning features between 2002 to 2009 was a significant milestone in that it aligned with Tim Berners-Lee's (the founder of the *World Wide Web*) view that the web was meant to foster a "read-write relationship". This meant that users were not meant to solely consume information from the web, but also to share our thoughts and participate in online discourse.

In the late 2000s, there was a lot of development in new tools and technologies which resulted in a structural shift toward social learning. The rise of social media applications such as *Facebook* and *Twitter* allowed users to connect with people from around the world and be able to hold a "distributed decentralised global conversation" around things that we cared about.

**Media-Rich Web**

The late 2000s decade also saw the rise of video-based lectures from MOOC providers such as *EDX Coursera*. So instead of lecturing in a classroom, an educator could lecture on video and upload that online. Pedagogy and teacher-learner dynamics were not significantly different during this time but there were more media-rich opportunities available. Despite this, one of the drawbacks of this development was the slight pullback from the collaborative dynamics of

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web 2.0 and the increased role of the teacher in the classroom. Nonetheless, there was a sense that this was an opportunity to increase the richness of digital learning.

**Immersive Stage**

We then entered the stage that has yet to fully realise its potential—the immersive stage. During this stage, students are taught with a completely different perspective leading to a shift from traditional modes of learning to social constructivist pedagogies, problem-based and game-based learning. We are still at the early stages of this and there is some concern about whether this is a significant, scalable educational approach.

Some of the challenges facing game-based learning (including Virtual and Augmented Reality [VR and AR] approaches to learning) are the high costs of development and the misplaced expectations of students. For instance, while students as avid gamers may be impressed with the features of popular games like *World of Warcraft*, they may be less impressed and interested with the quality of some educational games. As such, while VR and AR would have much higher adoption rates in domains like medicine because of the tactile hands-on dimension, it is unlikely that such innovations would play a significant role in the education sector.

**Artificial Intelligence and Related Technologies**

The most recent trend in education has been the rise of Artificial Intelligence (AI) in learning. Although there is a growing hype around AI in education, the reality is that its implementation has been limited. This is because the current emphasis of AI application has been on the administrative dynamics of learning such as grading assignments and automating attendance taking. While that is useful, it does not raise the overall bar of the learning process. Consequently, AI applications in education, for the most part, rarely focus on the science of learning but bolsters the administrative system of learning. Thus, while there is a lot of automation that is supporting the learning system, they are not necessarily central to the main outcomes of learning.

There has also been the development of technologies that accords users with a greater degree of control. Platforms like *Blockchain* and cloud-based systems have been growing in traction. The rise of these tools represents a shift in the conversation from openness ideologically to openness as a concept of accessibility. There has also been a range of peripheral attributes around learning activities. Some innovative programmes such as *Jupyter* notebook contains an integrated learning and programming environment where one can practice while learning. Moreover, while there has been personalised and adaptive systems for instruction, most tend to be domain specific and narrow.

**Systemic Innovations: Start-Ups**

Education is one sector that has yet to fully globalise—which means that it does not have the efficiencies that can be exploited in other sectors. Nonetheless, there are early signs of international collaborations between educational institutions. For instance, some American universities such as Cornell University are setting up international outreach centres in countries like Qatar. Similarly, some Singapore universities have established collaborations with American universities. Some education institutions are investing in start-ups (or satellite campuses) in different countries that allow for other universities to benefit from innovative approaches and receive assistance around curriculum development. These collaborations hold numerous advantages including improving access to education

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for students, reducing the cost of education and utilising these networks and partnerships to generate efficiencies.

At the same time, there has been an enormous explosion in the educational eco-system in terms of educational start-ups. According to CrunchBase, there are some 3,300 start-ups in the educational sector specialising in a diverse range of areas including language learning, managing messaging with students and other complex personalised learning systems.

**Learning Sciences/Research**

There has been a surge of interest in learning sciences and learning research driven partly by technologies out of left digital trails and the technification of society. Specifically, learning analytics and learning sciences are two areas that are receiving a growing interest from government and funding agencies. As mentioned, this growing interest is also bolstered by educational data sources that are available in MOOCs from universities such as Unizin that have coordinated networks of universities to reduce overall costs.

This increased interest in the learning sciences and research has also led to a growing awareness that the role of technology is not solely limited to augmenting existing learning practices. Rather, technology has the capacity to extend and alter our engagement with information and our teaching and learning practices.

**Application of Pedagogies**

With the increasing emphasis on learning sciences and research, it has also led us to question our existing pedagogies—how do we teach the concepts and guiding principles that we should employ in practice in increasingly technological settings? There are three perspectives that could be useful in addressing this query: 1) cognitivism; 2) constructivism; and 3) connectivism.

1. Cognitivism

Cognitivism seeks to explain mental states. It focuses on questions of goal orientation and answers questions such as: Why is one person able to exhibit better self-regulation than another? How do memory processes work?

2. Constructivism

Over time, we have witnessed students increasingly become effective agents of their learning in the classroom—students are building their own knowledge, participating more broadly in discourse and developing different kinds of deep conceptual insights. One explanation for this can be found in Thomas Kuhns' "The structure of scientific revolutions", which posits that the notion of objectivity is not completely "objective", and there is a range of dynamics that influences what constitutes knowledge and meaning-making. This idea fits into an ongoing discourse within scholarly education that with the increasing emphasis on 21st century core competency skills, there are some aspects of soft skills that are difficult to quantify and understand.

3. Connectivism

Networks form an underpinning model that demonstrates what happens when we learn. I argue that networks play an integral role in the conception of knowledge—starting with the conceptual structure of our neurons connecting through to how we develop ideas and how we subsume and augment what we already know with new knowledge, and increasingly, how we connect with other people. Most of us do not store knowledge exclusively in our heads; we store it in technological artifacts and within our social networking. Thus, our knowledge is not solely the product of our individual minds but also a collective product of our networks.

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These technological and pedagogical innovations have led to huge systemic changes. The surge of global partnerships and global learning activities have been driven by these technological and pedagogical advancements in learning theories. In short, technology has enabled us to reach out and be connected through global networks.

**Problems**

There are some growing issues that school and university systems are facing because of networks. One such issue is the rise of disinformation and the increasing politicisation of society. Networks have blurred the lines between our personal and professional lives regarding our belief systems. In the past, you could adhere to a political system of belief that can be left out of the classroom. However, with the rise of social networks, individual beliefs have increasingly informed teaching.

Another concern is the increasing redundancy of jobs as a result of automation. There has been a mindset shift toward this idea of learning as constant. Due to our fear of obsolescence by increased automation, we are consciously engaged in ongoing learning. This constant engagement of learning as an ongoing process is a consequence of the notion that knowledge is provisional. The implication is that knowledge is not immutable, it changes with new evidence and self-corrects itself. One consequence of this provisional nature of knowledge is the psychological impact of feeling like not being in control. It induces feelings of anxiety of having to constantly learn and "get on top of things" in our daily tasks to maintain control.

While such advancements have presented increased opportunities and choice, it has also highlighted the inability of universities to adapt to this new reality that in terms of education, they are not the only choice. For example, recent initiatives by groups like Amazon have invested 700 million dollars into upskilling employees at AT&T and Microsoft. A Kegel survey recently pointed out that 59 percent of the people working in the data science field got their education through MOOCs, or on their own. This basically meant that they bypassed the university system. However, it is important to note that they likely still interacted with a faculty, outside of a university classroom. Nevertheless, this highlights a growing concern with the university system.

**Benefits and Limitations of Technology**

Technology has advanced a new infrastructure for more interactions and engagements. While cognitive technologies are still being developed at the early stage, technology has undoubtedly contributed to the formation of a new space for knowledge to develop and flourish.

One drawback from technology, however, has been the declining importance of learning. Conventional wisdom holds that as more information is made available by technology, learning should simultaneously become increasingly important. But the more information that is available at a faster rate, learning may decline in importance because new information may become obsolete at a rapid pace. In turn, this results in sense-making and meaning-making increasing in importance. To assess the validity of new information and ideas, we need to have a system for interacting with and recognising information as you encounter it. Although technology has the capacity for clustering and organising information effectively, it is limited in assessing the validity of information. This, as a result, alters our relationship with new information. Technology alters our reliance on certain kinds of memory and changes the types of cognitive approaches that are most consequential and valued.

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**Two Substantial Challenges**

1. Coherence

The fragmentary nature of technology networks presents a problem for the education system that is reliant on coherence formation. Our classrooms have a structured way of leading students through a particular set of courses to produce a coherent understanding of a subject matter. The problem arises when students, through their self-regulated learning, encounter new information through technology in fragmentary ways leading to huge blind spots in understanding. As a result, students may have difficulties in consolidating disparate pieces of information. The role of educators then is to support individuals by developing an integrated and coherent view of a knowledge scape so they can address the gaps in information and identify research opportunities.

2. Understanding

Because we have such ready access to information, most of us may only have a surface level understanding of a subject. This is what is termed as "the illusion of explanatory depth", where individuals may have incomplete or partially developed information on a topic. But does it matter? For educators, I would argue that it is a critical issue as there is a need for an integrated, coherent and comprehensive framework and worldview to inform us of things we do not understand.

**Implications**

What are the curricular implications of technology in education? What is the impact on your pedagogy and on your teaching and learning practices? How do we navigate complex intractable information landscapes? How do we make that transition? Regardless, our objective should be to develop our students with attributes that foster engagement, recognises the dynamics of complexity and the importance of communal knowledge, and how we navigate the future with this range of complex technology and cognitive agents.

# THE FUTURE OF LEARNING: THE POTENTIAL OF ARTIFICIAL INTELLIGENCE FOR EDUCATION

**PROFESSOR GEORGE SIEMENS**

**10 OCTOBER 2019, PUBLIC LECTURE, LIFELONG LEARNING INSTITUTE, SINGAPORE**

**Synopsis**

**THIS TALK EXPLORED** developments in human and artificial cognition, and the intersection of these two advancements in shaping the future of learning. Professor George Siemens argued that we are entering a post-learning age, a period where the traditional cognitive functions performed by learners can increasingly be performed at higher levels by artificial agents. In a post-learning era, our focus will turn to "being" skills. These skills include creativity, kindness, compassion, generosity and attributes that have a long historical basis in human history. The ways that human and artificial cognition overlap to form the basis of future society are also explored. The following is a transcript of the public lecture.

**Introduction**

The advancement of technology has transformed our education landscape and altered our approach to lifelong learning, corporate learning environments and the K-12 system. We are witnessing a phase where the competitiveness of the education sector is now a global concern. As part of the early stages of the globalisation of education, there are universities actively expanding into new parts of the world. In the western hemisphere and the United States, there is an incredible array of educational technology start-ups, many of which are now exceeding the billion-dollar evaluation.

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There has also been an enormous rush in attention to things that we would classify as "non-cognitive"—the idea that there is more to the learning process that encompasses emotional and affective attributes. The increasing automation of the workforce has not only challenged physical work, but also cognitive work. Induced by the growing prominence of "Artificial Intelligence (AI)", the term has become somewhat useless due to its multiple meanings. Therefore, in this lecture, we seek to better explicate what AI means and its potential for education.

**Knowledge Generation: Moving to Networks**

There has been a dramatic shift from the centrality of the teacher to the structure of the network as being the vital agent that underpins knowledge work. This puts us in a position where we must consider two fundamental questions:

1. What's the conceptual framework that we can use to guide our thinking as we try to process these changes, bearing in mind the social and racial disparities faced by countries?
2. What can we do within the education system to help make the process least damaging to people to help them better prepare for a complex, globalised and connected world?

One way to address this is through the lens of networked learning or specifically, through connectivism, which is the theoretical framework that knowledge is networked and that when we engage in learning processes, it is part of growing and pruning those networks. Connectivism can happen in a number of social systems and levels—the individual or team level, or it can be specific to a domain such as physics, medicine, biology or a function of culture. In the next section, we will discuss the three levels where connections are forged when we observe learning.

**Networks of Learning**

When learning, we are involved in a knowledge creation process which are essentially networked activities at three fundamental levels: neural, conceptual and external.

i) Neural Level

Cognitive processes find their basis in neurons. When neurons engage and connect in our minds, it forms a by-product of our coherent view of the world. There are bio-chemical processes that underpin our experience of life and our capacity for cognition. Memory, in the same regard, is also a networked property. When we encode, access and retrieve memories, our mind is engaged in networked recall processes. For example, when you attempt to recall a piece of information, that information does not merely sit in one part of the brain and your neurons must run to that part to retrieve it. Rather, knowledge is not confined to one place in your brain; they are networked and connected throughout your mind. In essence, when we learn, our neurons form connections which sets off an entire sequence of mechanisms that interprets cohesion forming, consciousness of reality and distinct cognitive processes such as interpreting complex activities, reflection, engagement and knowledge production.

ii) Conceptual Level

Cognitive scientists argue that one of the defining attributes distinguishing humans from animals is the capacity of humans to experiment with concepts. A dog, for instance, likely has no concept of timing or a schedule of activities in a day. Humans, on the other hand, are aware of time as a finite concept and are inclined to manage our schedule to optimise time. Similarly, this is what we do when we learn—we are involved in the process of connecting, interacting and integrating various concepts.

iii) External Systems

At a broader level, networks have an impact on the intelligence of organisations. The intelligence of an organisation is defined largely by its people and the connections between those people. Organisations, as a result, exist to foster environments for individuals to engage with one another and produce things that would otherwise not come to fruition if individuals were left alone.

**Influence in Artificial Cognition**

The increased use of cognitive agents or artificial cognition in our daily lives is changing our daily practices and living habits. It is changing how we schedule our day, how we book appointments for a restaurant, how we explore and discover new ideas, or how a piece of news is a valid or meaningful source of information. Due to the growing prominence of artificial cognition, we need to think about how human and artificial cognition intersect.

More specifically, we need to think critically about the relationship between artificial cognition and teaching and learning in higher education. When teaching students, we are—in a manner of speaking—writing our values on to future generations. Thus, when interacting with students, the way that we automate parts of the teaching process matters. This is because while it might be effective in the short term to address a student's query or problem through an artificial approach (such as by directing their attention to notifications and pings), in the long term, it may inhibit a student's self-regulatory learning. As educators, one of the critical questions we need to ask ourselves is how do we place artificial agents in the curricular process in a way that enables future performance but does not compromise on the developmental capabilities of our students?

Another question pertaining to artificial agents is: How is it different from existing forms of technology such as the computer? One of the primary distinctions of the artificial agent is its shifting function from being a tool to being a quasi-colleague or eventually even a type of colleague. In other words, when we use an artificial agent, while it might accomplish its task, it also changes us in terms of our social and cognitive practices. A relationship with a cognitive agent is one that provides us with feedback and responds to our actions, and through this process, changes our behaviour. Put differently, artificial agents are entities that think *with* us and not things that we *use* to think. While this distinction is small at this stage, it continues to grow in significance the more deeply we fall into a future that is data-driven and computationally managed. It is worth noting that on several levels, our engagement with artificial agents are producing uneven impacts on some of our core cognitive processes such as attention regulation. One of the most critical attributes that we need to teach our students is the ability to focus during self-regulated learning.

**Definitions**

Prior to delving into the dual systems of artificial and human cognition, it would be useful to define these terms to better apprehend their specific functions.

***Cognition***

Cognition is essentially the combination of sensory processes, mental operation and complex integrated activities that are involved when we interact with information. Based on this definition, sensory processes relate to things that are observational, audible or tactile. Mental operations relate to things like memory and encoding, while complex integrated activities involve planning, forecasting, synthesising and evaluation.

# THE FUTURE OF LEARNING: THE POTENTIAL OF ARTIFICIAL INTELLIGENCE OF EDUCATION

PROFESSOR GEORGE SIEMENS

10 OCTOBER 2019, PUBLIC LECTURE, LIFELONG LEARNING INSTITUTE, SINGAPORE

***Artificial Intelligence***

According to the Stanford hundred-year study on Artificial Intelligence (AI), AI is broadly defined as the science and the set of computational technologies that are trying to duplicate what humans do. It is inspired by our nervous system and how it feeds information to our brain. The study of AI is largely concerned with creating intelligent machines. Machine learning, specifically, is mostly concerned with the ability for software to learn or to develop without being explicitly programmed. Deep learning and neural networks are one of the areas that most closely links to neuroscience where the focus is on neural models and neural networks that bears some degree of structural articulation with the human brain.

One category of AI that most of are familiar with is artificial narrow intelligence. This refers to a software programme or an algorithm that performs a particular task well but is limited to a specific domain. Conversely, if the AI is reapplied to another domain, its effectiveness may be hampered, and it may have to be retrained with the systems in the particular domain. When this technology is applied to the emotional engagement space, this may affect the level and quality of interaction with the AI tool. In other words, the more emotionally engaged and cognitively active a user is from a human end, the more sophisticated the interactions between these different agents becomes. Essentially, there are different ways of rendering and representing intelligence in both biological and technological entities.

A key question that is being addressed with AI in relation to the labour market and job security is—what can AI do and what would be left for humans to do? We know that AI is effective with a plethora of activities including speech recognition and investments. But how well can AI do these tasks compared to humans? Considering that most investment trades are now algorithmically driven, we can establish that AI is doing well in that area. But how many parts of these cognitive capabilities can AI take from us until we start to question our sort of existence in the world? An approach to addressing this would be to look at human and artificial cognition and the ways in which both systems overlap. The nexus of human and artificial cognition would have implications for our role in organisational settings, teaching and learning in classrooms, and the kinds of skills vital for future industries.

**Artificial and Human Cognition: An Integration**

How do we treat the dual systems of artificial and human cognition as working together? One challenge of AI systems is the increasing speed and response to computer-oriented systems which enables it to generate new behavioural regimes as humans lose the ability to intervene in real time. As our technologies evolve, there are instances when our technologies are vastly outperforming human cognition. In essence, we will be witnessing a stage where core cognitive processes will be duplicated at a level that outperforms human capacity. At that point, these systems would have achieved what we would call 'artificial general intelligence'.

As previously discussed, artificial *narrow* intelligence performs a specific task well but has limited transferability to new domains. Artificial *general* intelligence, on the other hand, is a system that acts and performs like a human being and has the ability to learn and reason and interact with the world. What is the impact in the classroom given that an AI system can do a particular cognitive task better than a human student? How do we design our curriculum to enable our students to better reap the benefits of AI systems in the workplace? Moreover, while some tasks are more

effectively executed by AI systems, there is a need to acknowledge that there are assignments that are better served by humans. Technology has its limitations in performing work related to the core human experience. Thus, tasks centred on the human experiences and its various emotional attributes including, but not limited to, compassion, kindness, joy, and the ability to imagine and envision a future that has yet to exist are better suited to be carried out by humans.

**What Can AI Do?**

AI has been effective in, but not limited to, the following tasks: decisions in terms of modelling, discovering patterns and trends, large scale computational work, structured and computationally heavy rule-bounded activities, understanding images, and speaking to humans. Nonetheless, while AI is effective in several routine oriented activities, it lacks some core cognitive capabilities such as understanding meaning and intent.

Moreover, AI systems are liable to cheating. This means that if you set an objective for an AI tool to achieve while also being bounded by rules, the AI tool may accomplish the objectives but not in the way it was intended. For example, a self-driving car that was rewarded for speed decided that the most effective means of achieving its goals was to spin in circles. While technically achieving its objectives, passengers in the car would get sick in the process. In another instance, in a game where the objective was to defeat the enemy which entailed not dying in the game, the AI tool learnt that if the rule is not dying in the game, then it could pause the game indefinitely. Hence, the key learning point is that while certain tasks can be performed intuitively and rapidly through human cognition and AI systems, this needs to be followed up with a lot of training and (re-)writing of rules for the AI systems.

**What is Unique to Human Cognition?**

There are compelling lessons to be drawn when comparing the difference between humans and animals in terms of a cognitive scale. One unique attribute of human cognition is the ability to interpret symbolic representation from a range of inputs. For instance, humans can experience a range of emotions from symbolic representations such as in the arts. Another aspect of human cognition is the ability to move into different modes of thought, for example, from sensory inputs to perceptual to reasoning. On the contrary, artificial cognitive agents are too literal and unable to deal with disambiguation—such as when making jokes and detecting emotions.

One of the most significant issues with AI systems, in general, is that knowledge is treated as a consumable entity rather than something to be acquired and then applied. Human knowledge, however, does not work that way. A large part of human knowledge is culturally and socially embedded in our systems as values and is transferred through “osmosis”, observation and mentorship to the next generation.

**Post-Learning**

In recognising that artificial cognition is developing at an astounding pace and that new tools and technologies can exponentially ramp up the previous performance of these systems, where does that leave us? If AI is more proficient than humans in recognising images, translation, and performing cognitive-based activities, what is left for humans? If you were tasked with designing your school system and that in five years, artificial cognition would be operating at a general intelligence level, how would you design your school system and curriculum?

# THE FUTURE OF LEARNING: THE POTENTIAL OF ARTIFICIAL INTELLIGENCE OF EDUCATION

PROFESSOR GEORGE SIEMENS

10 OCTOBER 2019, PUBLIC LECTURE, LIFELONG LEARNING INSTITUTE, SINGAPORE

This, I would argue, would be defined as a "post-learning era" where sense-making and meaning-making becomes more important. Sense-making and meaning-making are defined by questions such as: What do these things mean to us? And how do we make sense of this constellation of patterns that are coming to us daily?

In this era, learning can be done by artificial systems at a level that far outpaces human capabilities. However, the kind of knowledge that artificial systems would master over humans is very specific—mostly knowledge that can be codified, acquired, and then applied. Knowledge that is communicated culturally, musically, structurally, artistically and creatively is difficult for an artificial system to acquire.

Thus, in the post-learning era, we need to embrace this idea of "beingness". In other words, we need to cultivate the attributes that make us human. In education, one of these attributes include attention preservation. The ability to self-regulate and use our attention in wise ways is a fundamental task that many of our students are failing in. Andrew Ng, the American businessman and computer scientist working on AI, once remarked that if a task takes one second of mental activity, it could probably be automated. A lot of the tasks that we are currently engaged in are short knowledge activities. Our mind is constantly bombarded by multiple streams of information and we need to get to a place where we can understand and process what that means for human values, norms, and other things we care about. We need to get to the point where we recognise that while artificial systems are effective in specific knowledge activities in the classroom, it is unable to comprehend and process "beingness" the way humans do. To that effect, there has been a growing focus in the learning sciences toward understanding emotions, affect, developing discourse, kindness and compassion.

**Sense-Making and Meaning-Making**

Sense-making and meaning-making is a domain we need to strengthen so that we may be able to comprehend the world around us in a substantive way. We want to see the implications of the various trends and challenges we are facing, not just at the personal level in terms of our environments in school settings, but also at a societal level.

One of the current challenges we are facing in the human-machine frontier are workplace disruptions and redundancies caused by technological advancements in AI. Thus, one of the biggest trends in terms of economic output, at least in the United States, is rescaling—where investments are being made on upgrading workers' skills or redirecting them to new careers involving machine learning, data science, or healthcare fields that are rapidly developing. Moreover, our efforts should not only be concentrated on the youth but adults as well. Amazon, for example, recently announced a 700-million-dollar initiative to retrain their core staff in a range of topics. The question that remains: What do we do in a post-learning environment? There is no answer to this question but rather, it is more of an ongoing conversation.

The post-learning era will involve thinking and learning with machines, not as a tool, but as co-agents in our knowledge work. Moreover, it is an era where many key human cognitive tasks such as memory work would be offloaded to artificial systems. For instance, instead of relying on our memories for information, we would depend on artificial systems to seek out information. Nevertheless, we need to be mindful that memory is a very critical cognitive activity that is developmentally consequential. As such, while we may still need to memorise things regardless, we also need to reassess our curriculum to complement the needs of this new era.

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**Living in a Post-Learning Age**

Consuming information is far less important than our relationship to continuous learning. If you are working in a school environment, or a research centre or government agency specialising in education, some of the questions you may want to ponder include: How do you develop these individuals toward lifelong learning through learning and engagement? How do you build a lifelong pipeline for them to continue to learn or embed them in a lifelong ecology that will enable them to be continuously engage in learning? How can we adapt technology to better cultivate group work and collaborative learning?

These are issues that we need to contend with in an era where sense-making, meaning-making, and wayfinding becomes the primary and the most consequential knowledge activities that we undertake in our classrooms, schools, organizations, and corporate teams and ultimately, in our actions and activities as a society.

# FEATURED ARTICLES ON ARTIFICIAL INTELLIGENCE FROM NIE SCHOLARS

| /N | Title | Author | Journal / Edited Book | Year | Summary |
|---|---|---|---|---|---|
| **1** | Educing AI-Thinking in Science, Technology, Engineering, Arts, and Mathematics (STEAM) Education | How Meng Leong and Hung Wei Loong David | Education Sciences | 2019 | In science, technology, engineering, arts, and mathematics (STEAM) education, artificial intelligence (AI) analytics are useful as educational scaffolds to educe (draw out) the students' AI-Thinking skills in the form of AI-assisted human-centric reasoning for the development of knowledge and competencies. This paper demonstrates how STEAM learners, rather than computer scientists, can use AI to predictively simulate how concrete mixture inputs might affect the output of compressive strength under different conditions (e.g., lack of water and/or cement, or different concrete compressive strengths required for art creations). In applying AI to think discursively, AI-Thinking can be educed from the STEAM learners, thereby improving their AI literacy, which in turn enables them to ask better questions to solve problems. |
| **2** | Semiotics, memory and augmented reality: History education with learner-generated augmentation | Kenneth Y. T. Lim and Ryan Lim | British Journal of Educational Technology | 2020 | The project reported in this paper aimed to broaden the application of AR in education, specifically to history education, by exploring the affordances of such technology in mediating student-led learning activities, using an approach known as learner-generated augmentation. The study involved the design of a learning activity to help students memorize historical information more effectively by building upon the established memory technique of Memory Palace/method of loci. In this activity, students used a free AR mobile application—Just a Line—to sketch out memory palaces of key information from a prose passage. No claim is made with respect to the absolute efficacy of the approach, given the limited number of participants in the study. The intent of this paper is instead to invite exploration and debate around the wider affordances of AR for learning. |
| **3** | Mobile Computer-Supported Collaborative Learning | Looi Chee-Kit and Wong Lung Hsiang | In Fischer, F., Hmelo-Silver, C. E., Goldman, S. R., & Reimann, P. (Eds.), International Handbook of the Learning Sciences (PP. 368-380) | 2018 | This chapter provides a summary of research and development in the field of mobile computer-supported collaborative learning (CSCL). The authors explore the synergies between CSCL approaches and mobile learning approaches. The characteristics and affordances of mobile technologies, and contemporary mCSCL learning designs and practices, and postulate future trends and developments in mCSCL research will be discussed. |

# FEATURED ARTICLES ON ARTIFICIAL INTELLIGENCE FROM NIE SCHOLARS

| /N | Title | Author | Journal / Edited Book | Year | Summary |
|---|---|---|---|---|---|
| **4** | Promising Ideas for Collective Advancement of Communal Knowledge Using Temporal Analytics and Cluster Analysis | Alwyn Vwen Yen Lee and Tan Seng Chee | Journal of Learning Analytics | 2017 | Analysis of ideas and related processes is critical for collective knowledge advancement in knowledge building discourse but is challenging due to large and complex discourse data. This paper contributes to the field of learning analytics by proposing a method that combines temporal analytics and unsupervised machine learning to analyse promising ideas and investigate idea mobility in discourse. Findings show that temporal analysis bridges the gap between individual analyses of discrete events to provide a broader picture of online discourse that is complementary to machine learning techniques and provides insights into idea-centric discourse. |
| **5** | Towards a TPACK-fostering ICT instructional process for teachers: Lessons from the implementation of interactive whiteboard instruction | Joyce Hwee Ling Koh and Shanti Divaharan | Australasian Journal of Educational Technology | 2013 | This paper describes an on-going design-based research project that aims to develop an instructional process to facilitate pre-service teachers' technological pedagogical content knowledge (TPACK) development as they learn to integrate information and communication technology (ICT) in their teaching content subjects. In conjunction with an initiative to prepare pre-service teachers for integrating interactive whiteboard (IWB) in their teaching subjects, an instructional process comprising of tutor modelling, hands-on exploration, and group-based design was implemented. The data collected during this first implementation cycle (Cycle 1) was used to enhance the second implementation cycle (Cycle 2) through the inclusion of classroom-based case studies, subject-based design ideas and opportunities for peer sharing. The findings from both implementation cycles reveal that strategies such as tutor modelling and hands-on exploration of ICT tools appeared to be more advantageous for fostering technological knowledge and technological pedagogical knowledge. |

***About the CJ Koh Professorial Lecture Series***

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