IBM Education

Personalised education

From curriculum to career with cognitive systems

IBM

About the research

In this research we set out to find out how educators are using digital education services and cognitive systems to deliver personalised education. We wanted to cut through the industry hype and understand from early adopters how it worked in real life. What are the challenges, what can we learn from successful implementations and what are the results? What did vendors think was possible and what did students actually experience?

The paper is based on four research inputs:

(i) In-depth interviews with 47 educational providers and 6 vendors in the USA, India, South Africa and the UK

(ii) A survey of 126 IBM interns based in the UK

(iii) Interviews with 3 IBM Watson partners who are working on cognitive systems for educators

(iv) Social listening from over 150,000 tweets relating to conversations around education

Terminology

Most countries organise their education systems into 3 phases:

1. Primary/Elementary	<12 years old
2. Secondary/High School	12–18 years old
3. University/College	>18 years old

We use the terms primary/elementary and secondary/high schools interchangeably, except where specifically referencing quotes.

Teacher – we use this term to refer to educators in primary/elementary and secondary/high schools.

Lecturer/Professor – we use this term for educators in universities/colleges.

Education management – we use this as an aggregate term to cover a range of management roles such as Provost, Vice-Chancellor and Head Teacher.

Data-driven cognitive technologies will enable personalised education and improve outcomes for students, educators and administrators.

Ultimately, education experiences will be improved when data can accompany the student throughout their lifelong learning journey.

In many parts of the world, education is considered to be in a state of systemic failure. This narrative is rooted in the belief that education is too expensive and fails to provide value for money. There is a growing disconnect between what education delivers and the skills being demanded in today's ever-changing global marketplace. The net result is that upon leaving full-time education, many young people are ill-prepared for the world of work.

At the same time, we are seeing unprecedented levels of change across industries and professions, with digital technologies serving as agents of transformation. Businesses are increasingly faced with a simple proposition: reinvent or die. In education, the same sense of pressure and urgency seems to be lacking. Educators may be lacking clarity on the correct path to pursue.

From our discussions with educators around the world, a harder-working, more dedicated and caring profession would be hard to find. At IBM, our view is that education's 'systemic failure narrative' does not have to play out in this way. We believe that education is potentially at the dawn of a new era, and in this paper we will explain how:

- despite challenges, digital education services are being embraced by educators.
- cognitive systems will enable personalised education and, ultimately, the education experience will be improved when data can be used to benefit students and the entire learning community.

"A major difference between healthcare and education is that if 50 percent of the patients died who entered a hospital, they would close the hospital. In education, if 50 percent of kids drop out of a high school – to become the 'living dead' – they bring in the next class." [1]

Education is evolving and, despite challenges, new digital services are being created by vendors and embraced by educators.

Over the past few decades, the role of technology in education ('EdTech') has continually evolved. In classrooms and lecture halls, 'chalk and talk' has increasingly been complemented by digital tools and platforms which typically vary in scope and sophistication according to where the student is on his or her education journey (Fig 1).

It's a digital world

It is clear that student appetite for digital tools across the whole gamut of education is strong. This fosters a learning environment that is more engaging, more 'hands-on', more meaningful and memorable and creates better learning outcomes. In a sense, this is a reflection of how today's students live their lives beyond education.

This is putting pressure on education professionals as they seek to meet the growing demands of 'digital natives'. As a primary teacher commented: "The kids we're getting now have grown up on technology. They're learning how to use it… They're a lot better than we are and that's a scary element."

Transformative approaches that may become more widespread include elements of gamification, whereby groups of students can connect and collaborate across different schools and geographical boundaries. Schools are experimenting with innovative 'glocal' classrooms where the lesson is brought to the student to overcome challenges of distance and income found in the developing world. Add to this the potential for virtual reality field trips, 3D printing and foreign language video conference sessions with schools in different countries, all of which point to exciting possibilities for students and educators.

> "The kids are very engaged with technology… Any time we can incorporate technology in a lesson, you're adding visual, you're adding audio, you're adding tactile. When they're hands-on with a piece of technology, it sticks better because we are using all modalities of learning"
> (USA high school)

Fig 1: Technology and digital solutions used in education today

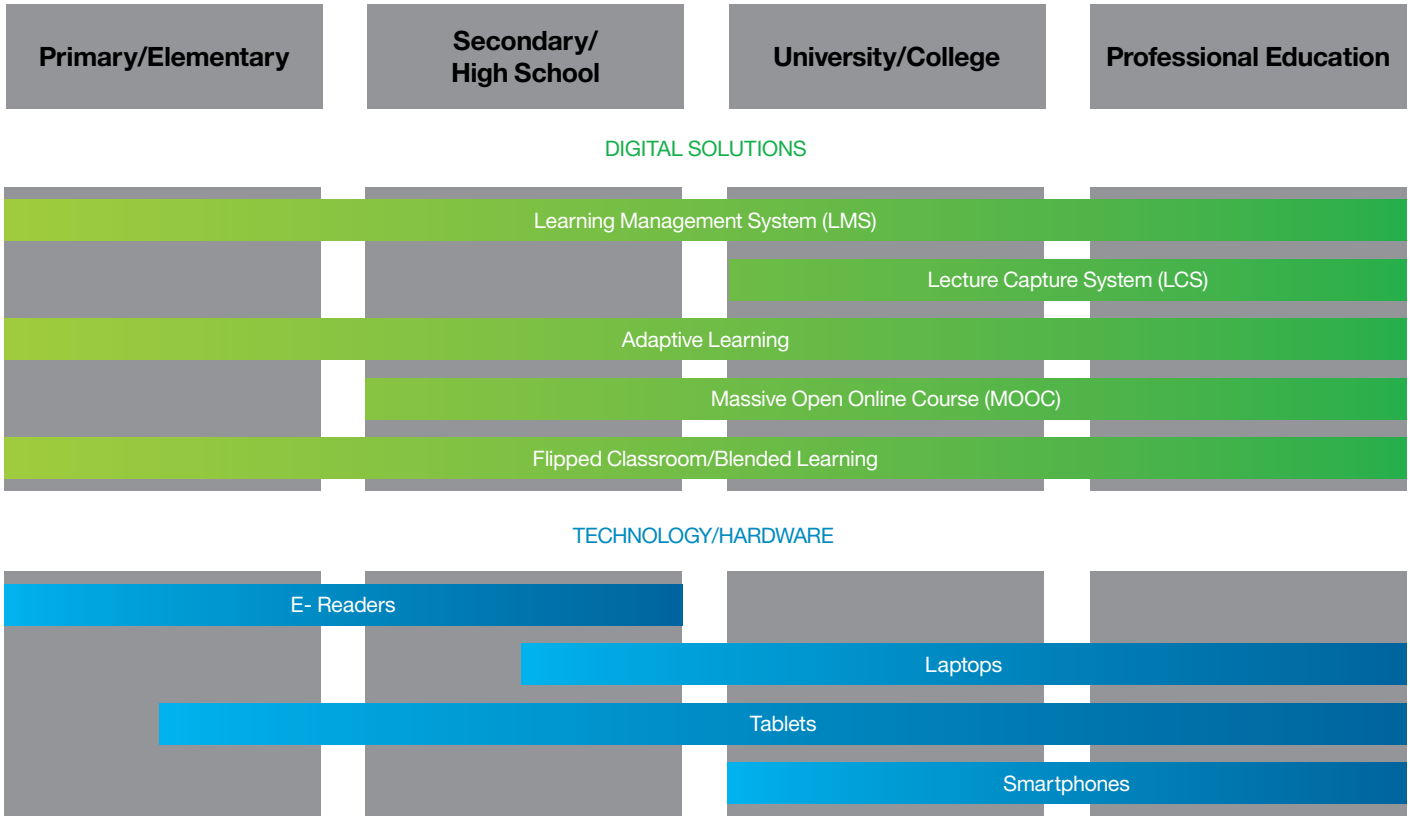
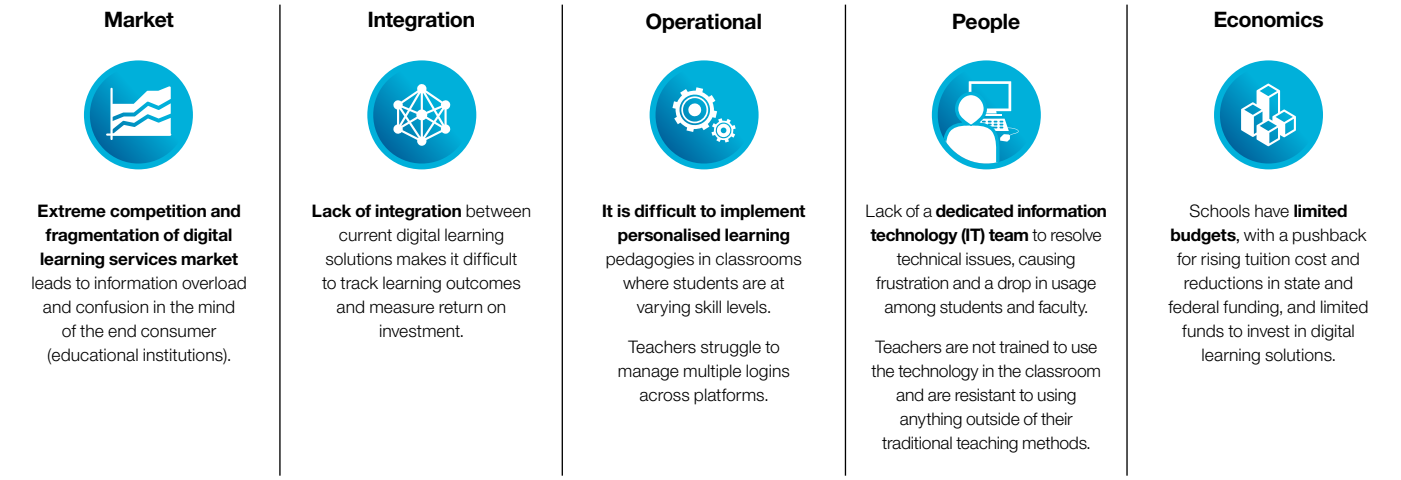


Fig 2: Challenges for the adoption of digital education today



It's not all a land of milk and honey

Educators may legitimately ask: "Haven't we been here before?" Many report poor experiences with technology which failed to deliver against expectations and was difficult to use and impossible to integrate with existing and new technologies.

Many issues conspire against greater use of digital technologies (Fig 2). Furthermore, concepts such as blended learning and flipped classrooms simply cannot be implemented if students don't have internet access at home, and this is not just a developing world challenge.

The use of digital tools within educational establishments appears to be fairly laissez-faire, rather than strategic: "Experience of using digital services really depends on the lecturer. Some lecturers use it widely and some use it very little. There is no one practice in the university." (South African university)

There are also generational issues to consider. Many teachers never used such tools when they were learning and question their pedagogical efficacy. Moreover, educational professionals choose the extent to which digital tools are present in their teaching toolbox, if at all: "The major challenge is getting professors to deliver content in a digital form. Most professors have been teaching the same content for years and don't want to start delivering audio or video lectures and designing online courses." (UK professional education organisation)

There are also risk issues when it comes to adopting new digital technologies. Will new tools integrate with existing IT investments and will they meet curricular standards? As new vendors arrive on the scene, diversity of choice only adds to these risk factors: "One of the questions we have to answer is: are these resources meeting common core standards? Are they using state standards, or are they using district standards? My biggest challenge is I don't know what the best apps are out there to support my curriculum." (USA elementary)

While such challenges are difficult, they are not insurmountable. We identified a number of leading practices that educational establishments are testing and implementing (Fig 3).

Fig 3: Digital leading practices in education

Appointing a formal digital learning leader or team
Encouraging and rewarding teacher enthusiast, champions/ advocates and using them as mentors
'Reverse mentoring' – recent graduate teachers advising an older generation of teachers on digital tools
Focus groups to continually understand student needs
Digital armbands (flash drives) to permit offline working
Interactive and continuous training for teachers

Training the trainers

Many teachers are frustrated that training is inadequate and, because technology changes so quickly and upgrades are common, the sheer pace of change is difficult to keep up with. Consistently, the view is that training works best when it is not delivered as a week-long pre-term event, but is provided continuously, in bite-size chunks.

Institutions often implement staff mentoring programmes such as a 'digital champions' or 'buddy-up schemes' for colleagues to learn from each other. Many reported this often works through younger more tech-savvy teachers working with older generation teachers in a 'reverse mentoring' programme:

> "If 'old teacher in Room 30' sees 'new teacher in Room 31' and their kids are all fired up and excited walking out of that class, he/she's going to ask, 'What are you doing in there?' They'll reply, 'I'm doing this... I'll help you.' We try to get the teachers who are excited to be the evangelist for their department." (USA high school)

So rather than a top-down, vendor-led, training approach that is often difficult to digest in one go, the leading practice approaches are piecemeal, ongoing and informally driven by the staff themselves. As a primary teacher commented: "We have what's called Technology Thursdays, with different things offered each Thursday. It really has to be a gradual, iterative process. There are three of us who are technology-oriented. We've picked three other teachers that we work with."

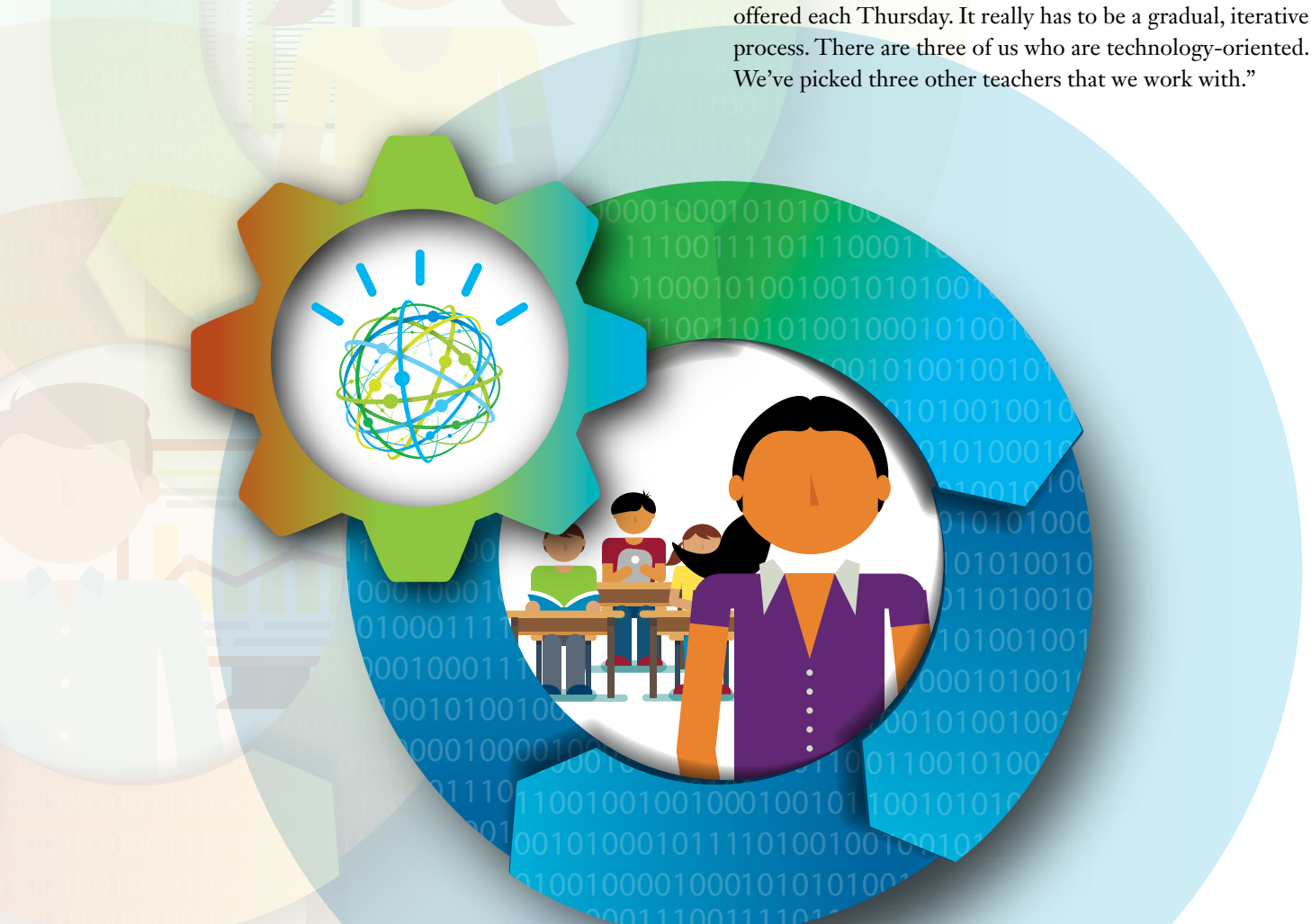
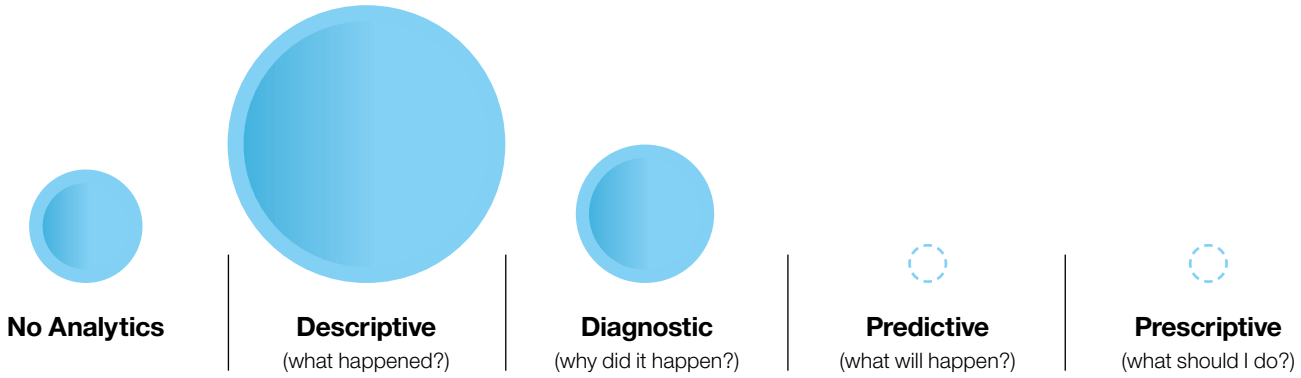


Fig 4: Most educational establishments are only using limited analytics capabilities



Note: Size of ball indicative of number of responses and the dotted circle represents no respondents.

How are analytics helping?

The majority of educational establishments we interviewed are using analytics in a limited 'rear view' way (Fig 4). This university's experience is fairly typical: "On the spectrum of analytics capabilities, we're at the diagnostic level. Our system can alert us to students' defaults and would usually tell us which students are at risk of failing. This is what we mostly use it for right now. I am sure it can do a lot more, but this is how we use it for the moment." (South African university)

Where analytics are used, existing tools are often under-utilised: "Our university isn't unique in saying our LMS (learning management system) has a lot of analytics within it, but they probably use 10% of this. A deeper understanding of analytics is going to be a big trend in the next 5 years." (UK professional education organisation)

We did not find much use of analytics to measure the efficacy of learning. The most cited reason is too many variables, making it impossible to isolate any one thing:

> "It's not necessarily one technology or two, so it's very hard to measure the impact. Generally, pass rates have gone up and retention rates have increased, but it would be hard to pinpoint if this is because of a 'flipped classroom'; there are so many reasons." (South African university)

This in turn may make the return on the investment in digital tools difficult to measure and justify.

There is certainly a role here for policy-makers. Recently, the UK government produced a consultation paper which sought to address the need for institutions to provide more insight on teaching efficacy through deeper analytics[2]: "The government's teaching excellence framework seeks to drive increasing use of analytics, and one of the challenges is to understand student pain. Are students having specific problems? Are they whizzing through stuff and achieving high standards meaning the course is too easy? These are all questions that can be answered with good analytics." (UK professional education organisation)

Data-driven cognitive systems will enable personalised education and improve outcomes for all.

While the tools and concepts discussed in the previous section have undoubtedly moved education forward, the impact of technology on education as a whole has been evolutionary rather than revolutionary. However, we believe that education is now on the precipice of a transformative next step: the capability to deliver learning on a more individualised basis. New digital tools, coupled with advanced analytics and cognitive systems (more on these later), will eventually facilitate the utopia of teaching – personalised learning.

As observed in other industries, when new digital tools gain traction, this eventually leads to a tipping point of mass adoption, and disruption is caused when the value proposition becomes so overwhelming it displaces the status quo (think Amazon or Uber). Ultimately, this culminates in the balance of power shifting to the end-user, in this case the learner.

As yet there has not been an 'Uber-moment' for education. We have, however, seen pockets of disruption taking place. Early successes have been found as a postscript to formal education in the form of MOOCs (massive open online courses). In these platforms, learners plug skills gaps with micro-level credentials and pull relevant content on demand rather than being pushed towards completing a one-size-fits-all course: "Rather than going through an entire certification programme, users are going through the courses they want to go through. We are seeing the balance of power shift to the end user, with more focus on timely training that solves the learning needs and a de-emphasis on certifications." (USA professional education organisation)

Another indicator of early-stage disruption is that 59% of IBM's interns said they were discovering digital tools themselves, versus 43% as a result of recommendations from faculty. In addition, we see the use of digital tools increase as students approach their university phase. One lecturer observed that "PhD students were very interested in talking about their use of MOOCs and access experts from all over the world".

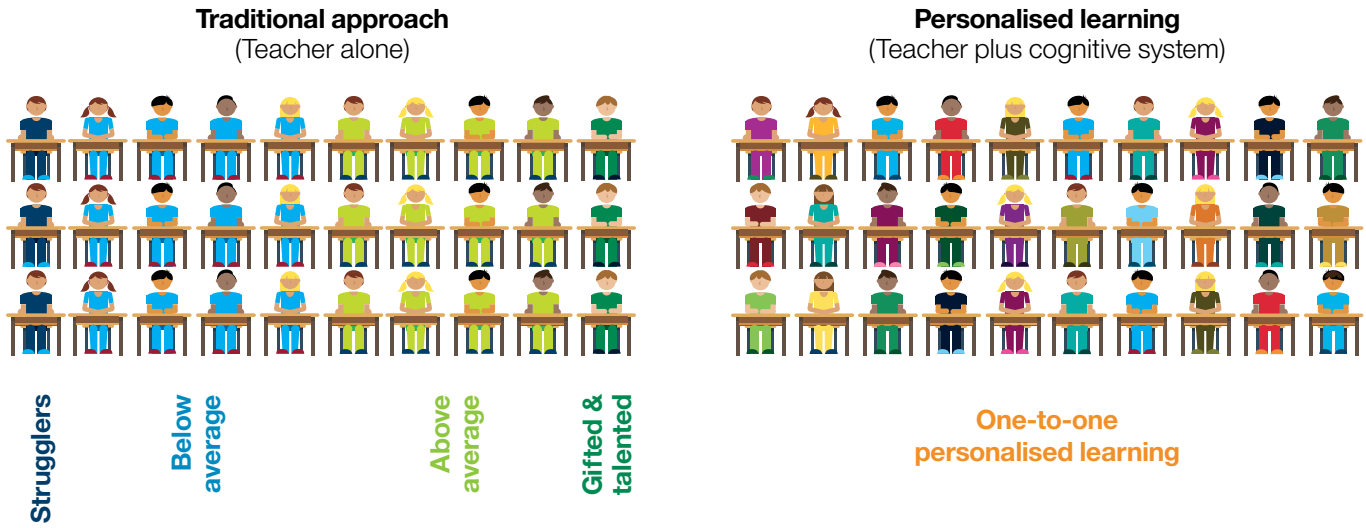
Elements of personalisation are also taking shape in traditional university settings to deliver a better, more holistic learning experience: "The thing that we're trying to do, particularly in our business school, is to personalise the learning experience. This supports the students far better in achieving their learning and education goals. I can actually see evidence that this is working at our university. We're trying to understand what is special about each individual so that we can help them meet their potential." (UK university)

Educational establishments are starting to talk about 'differentiated learning'. This marks the beginning of a step-change, moving education from a one-to-many homogenous experience to a one-to-one deeply immersive, personalised learning experience. Forward thinking establishments see digital tools as part of the answer: "Digital is so obviously the way to go. Traditional methods lack rigour and the ability to tailor learning to specific needs. Every child will learn at a different pace and currently we can't support each child. We have to bundle into 'special educational needs' and maybe 'fast learners', and they get most attention. This is clearly not effective." (UK primary)

"Deeply immersive interactive experiences with intelligent tutoring systems can transform how we learn."

Satya Nitta, Director, IBM Cognitive Sciences and Education Technology.

Fig 5: Evolution of education



"You're teaching to a bell curve. You've got your gifted kids in there and you've got your Special Ed kids in there. You've got to reach them all and that's very difficult."
(USA elementary)

"With technology it is easier to send each student down a different learning track. Once you do that, there are huge levels of possibilities. You are no longer restricted by just having one teacher teach 30 kids the same thing."
(Digital services vendor)

In a classroom of 30 students, a teacher typically divides a classroom into three or four cohorts of learners, as depicted in Fig 5 (left graphic): strugglers; a middle group which may be sub-divided into those above and below average; and a few higher achievers (gifted and talented). The promise of personalised learning is the delivery of a more customised approach (Fig 5, right graphic), where each and every child is treated uniquely and is always at their optimal level of learning.

While some educators are achieving results from deploying digital services, others are not. Of the educational institutions using digital education services, more than half said they had seen only very little or some impact on learning outcomes. Part of the challenge is that with hundreds of digital services available and a classroom of 30 students, there are too many variables for a teacher to handle.

Could it be that these services are necessary but not sufficient to achieve the utopia of personalised learning? Could some sort of teacher's assistant be required? What if an intelligent (cognitive) system could discover all the available resources, understand where they achieve their best outcomes and use this to create a personal plan for each student?

What do we mean by 'cognitive'?

Until recently, computing was programmable – based around human defined inputs, instructions (code) and outputs. Cognitive systems are in a wholly different paradigm of systems that understand, reason and learn. In short, systems that think.

What could this mean for the educators? We see cognitive systems as being able to extend the capabilities of educators by providing deep domain insights and expert assistance through the provision of information in a timely, natural and usable way. These systems will play the role of an assistant, which is complementary to and not a substitute for the art and craft of teaching. At the heart of cognitive systems are advanced analytic capabilities. In particular, cognitive systems aim to answer the questions: "What will happen?" and "What should I do?"

Cognitive Teacher Assistant

Teacher:
Cordelia, you did OK on your latest mathematics test, you got 72%. It looks like the algebra questions were areas where you struggled. Is that a fair assessment?

Cordelia:
Yes, I'm not sure I really get algebra. Are there any particular areas where I could improve?

Teacher:
Well, let's see what my assistant suggests.

Cognitive-enabled teacher assistant:
From an analysis of Cordelia's learning profile and her last five tests, algebra is a relatively weak area for her in mathematics. Based against learning outcomes of 1.2 million similar Year-8 students with matching learning characteristics, her understanding could be improved by either reviewing algebra module 2.3 or looking at instructional video 7.

Teacher:
Cordelia, I think you would find the video suits your learning style better. I suggest that you start with that and then we'll see how you get on.

The notion of cognitive systems to drive adaptive learning is certainly welcomed by the education profession:

> "To have some kind of prescriptive diagnostic programme where I could look at the actual question stemming to figure out which questions were most understandable and tailor our teaching to that student would be phenomenal and every teacher would be in love with that idea."
> (USA high school)

While establishments can see the value of cognitive systems, many see the realisation as a long way off. However, the future may be nearer than we think. For those students in education today, chances are they will still be working 40 years from now. It's a daunting question, but will the skills learned today still be in demand by then?

The world of work and education in 2056 is a reality for students entering the job market today

There is a popular doomsday narrative circulating today, with many predicting significant job losses as technology increasingly usurps mankind from the workplace. This is not our view. Across industries and professions we believe there will be an increasing marriage of man and machine that will be complementary in nature. This man-plus-machine process started with the first industrial revolution, and today we're merely at a different point on that continuum. At IBM, we subscribe to the view that man plus machine is greater than either on their own.

Today's millennial generation see it this way too. We asked IBM's UK-based interns what types of skills might be needed in the workplace 40 years from now. They recognise the need for continual skills development – 98% see a need to keep learning throughout their working lives – and they see a pathway to career longevity by focusing on skills such as communication, leadership, teamwork, problem-solving, people management and critical thinking. These skills underline the rising conflict between traditional education as essentially a memory test culminating in a 'paper and pencil' exam, versus modern skills-based learning which demands teamwork and problem-solving.

Cognitive systems are seen as a means to:

- improve speed of intervention
- reduce drop-out rates by creating better candidate selection processes based on more robust data
- identify students who may need extra help
- provide a richer analysis of why students fail tests
- ensure students are at the optimal level of attainment.

"The benefits of cognitive learning systems and prescriptive analytics are immense. We have students with vastly different backgrounds entering our system and personalised learning and early intervention would have a positive effect."
(South African professional education organisation)

A key cause of drop-out is when the pace of a one-size-fits-all course is beyond the capabilities of some students. As one digital provider explains, this can be addressed through systems that are more in-step with the learner: "If more students had access to adaptive curriculum material, it would make a tremendous difference in solving problems of high drop-outs and create better engagement in the classroom. If students were always learning within their level of proximal development, if they were always at the right level, you would have greater success."

In the 'IBM Watson Education Partners' table, we show how we aim to foster a better understanding of the immense capabilities of cognitive systems and how they can act as an enabler of improved student outcomes.

IBM Watson Education Partners

COGNOTION

Cognotion develops interactive videos and games to deliver mobile cloud-based training programmes to transform entry-level workers into skilled career-driven employees.

Cognotion introduced a cognitive capability into their healthcare product to educate nursing assistants – acting as a mentor or guide.

Founder and President Jonathan Dariyanani says

"I suspect that in the next 2-3 years there will be a mass disruption in the way people study and learn. If you want to intervene in education on a one-to-many basis (providing a customised, adaptive and responsive service) cognitive is a critical capability. Students do not want a linear experience but something that is tuned. It is not possible or efficient to do this using human controllers – only cognitive services and technology can operate at this scale."

SymSCRIBE

The recently launched SymScribe product captures from whiteboards and speech, normalises data and provides recommendations to teachers to identify where lessons and topics should be revisited.

Initially working with IBM on speech-to-text technology and now exploring the use of cognitive technology to provide feedback to teachers, CEO Jeff Ausfeld says

"Cognitive systems can help define and build the best algebra class possible based on what was well received or not well received."

MARi

MARi are currently integrating IBM Watson capabilities into their platform to build deep profiles of individuals to help employers match job vacancies.

CEO John Carney describes their focus on workplace performance acceleration as being similar to the moment in the Matrix when Neo says to Trinity "Can you fly that helicopter?" and she downloads the data and replies "I can now!"

John goes on to say

"If I said to you your life, job, career can be more like **you** want it if you did x, y, z... If I could tell you what your unseen limiting factors are and what to do about changing them from an education/skills point of view, you'd want that, right?"

For cognitive education services to be effective they need to be immersive experiences for the student, whilst being complementary to the art and craft of teaching. They also need to reduce the administrative burden on the teacher, effectively giving time back to teach.

We believe technology will help educators to improve student outcomes, but must be applied in context and under the auspices of a 'caring human'. The teacher-to-system relationship does not, in our view, lead to a dystopian future in which the teacher plays second fiddle to an algorithm. The teacher role changes to a higher value plane, with less focus on lesson creation/formal lecturing and an increasing focus on facilitating/coaching.

Increasingly, what we will see across teaching, and indeed all professions, is that tasks considered of value today will change in terms of how we come to perceive value over time. This is not a new phenomenon, but part of a natural evolutionary progress. Take, for example, the ability of a machine to assess 100 multiple choice answers in a matter of milliseconds. It does not get tired, does not need a break, and does not make any errors. We take it for granted today that such a task is ideally suited for a machine. In the future, systems will be capable of analysing essay-style answers, which will permit teachers to spend more time on higher value activities. This is a concept that is well articulated here:

> "A lot of teacher time can be taken up by analysing the answers to a long-answer based test. The insights don't come out very easily. There are things that might have come out of that test in another 10,000 cases elsewhere that they can't see. Comparing demonstrated answers and abilities and looking for those nuances using AI, you could generate a student profile that would be very helpful indeed for a teacher, who doesn't have the capability to analyse 10,000 tests." (UK secondary)

But cognitive systems are only as good as the data available to learn from (what we refer to as the 'corpus'). If the corpus is restricted to a single educational establishment or service, this is not as insightful as having access to a wider data pool, such as state-wide or country-wide data. In the following section, we explore the concept of electronic data education records to understand whether educators thought this would bring benefits, and what they thought might need to be resolved to make this achievable.

The education experience will be improved when data can accompany the student throughout their lifelong learning journey.

In healthcare, most developed countries have – to varying degrees of efficacy – a common data record in the form of electronic healthcare records (EHRs) containing lifelong data for individual people. It is useful to remember that this data serves two scenarios. In one scenario (the doctor-patient discussion) the data is personal to the patient and highly sensitive. In the second scenario (where the doctor searches all available medical data for a next-best action) the data is anonymised. Similar parallels exist in education with a personal record required to follow the student throughout their education journey, with the anonymised data corpus being used by cognitive assistants to help a teacher choose the best options for that individual student.

We tested the idea of a similar concept for education, whereby education records and digital learning platforms would all join up to offer a lifelong learning data record that could follow the student from primary/elementary, secondary/high, college/university onwards into education throughout their working lives. Those records would include more than test scores. They could include data on learning styles and difficulties that could be leveraged by other learning modules for the benefit of the student throughout his or her lifetime.

For the first scenario (a student's personal record) we found that in the main, the concept is welcome. One USA secondary teacher commented:

> "I lose valuable time working with new students because I have to start all over each year to understand that student, learn how they learn best and what modality fits them. If I had that data, before my students walk in, I could know exactly where I need to start with each one and how I need to present my lesson. It would be incredible." (USA secondary)

The idea of a universal digital education record can alleviate the problem exhibited by many education systems where each educational stage is siloed and has its own measures of success. Today, such systems in the transition phase (e.g. between primary/elementary and secondary/high schools) does not work smoothly, with the culminating effect of each failure in transition ultimately resulting in prospective employees saying they see far too many young people without the right skills.

Whilst such a data record has clear benefits to both student and educator, there are some key considerations such as the authenticity, privacy and security of data, including where and how data is stored.

> "Control has to be in the hands of the individual or it could lead to inequities. Say, you have children who go to schools that are terrible and they have these records from their early years. We know these schools have challenges… If you lose all these contextual variables that are impacting students' achievement and if that is not visible in such a record, it could harm people who are already marginalised in our society." (USA university)

We think many of the issues raised are resolvable and solutions are within reach. Indeed, there is evidence to suggest that when students see the value in sharing their data, they become more comfortable about the risks associated with sharing it[3].

We heard about various potential scenarios for addressing control and access to student data:

- Sharing of student records/academic certifications via a distributed database (such as blockchain)
- Students post their data record (in whole or in part) to a public repository such as Facebook or LinkedIn and retain ownership of who has visibility of their record
- An industry body or government creates a standardised solution and users grant access to others (educators, prospective employers) as and when required
- Users 'mash' their own solution based around various digital tools/platforms and provide their education credentials in the form of an e-portfolio.

Fig 6: Universal digital education records: Tipping point for mass adoption

Government Mandate

Government mandate is a necessary foundational step for a universal digital record to exist

Value for End Users

Students, job seekers, institutions, and organisations providing jobs must recognise universal digital records and see value in this information

Choice to Opt In

Individuals need the flexibility to choose information they want on the record. This could include an e-portfolio of their achievements

Source: IBM / Frost & Sullivan

While most of the issues for the student's personal record are related to privacy and security these problems disappear when looking at the use of large volumes of anonymised data to help a teacher choose the best personal options. Technically, such a common data platform and the cognitive systems that could drive such a platform are closer than many think.

"Anything that would provide information concerning how each student best learns would definitely help us in the classroom. As long as you're in the field of education and in the process of teaching, you have access to it, just like a doctor would. I think it'd be extremely useful."
(USA primary)

With such a rich data record, many interesting possibilities start to emerge. One example is a comprehensive career adviser system enabling the learner to query what he or she might be good at based on their lifelong record of skills and interests. This could uncover career pathways that might not have been immediately obvious to the individual. Another example could be reciprocal sharing of aggregated and non-identifiable data between academia and industry. The latter could better understand what student populations are learning and advocate changes to education to better match industry needs. In effect, we create a virtuous circle of real-time data that potentially solves issues relating to student leavers lacking necessary skills.

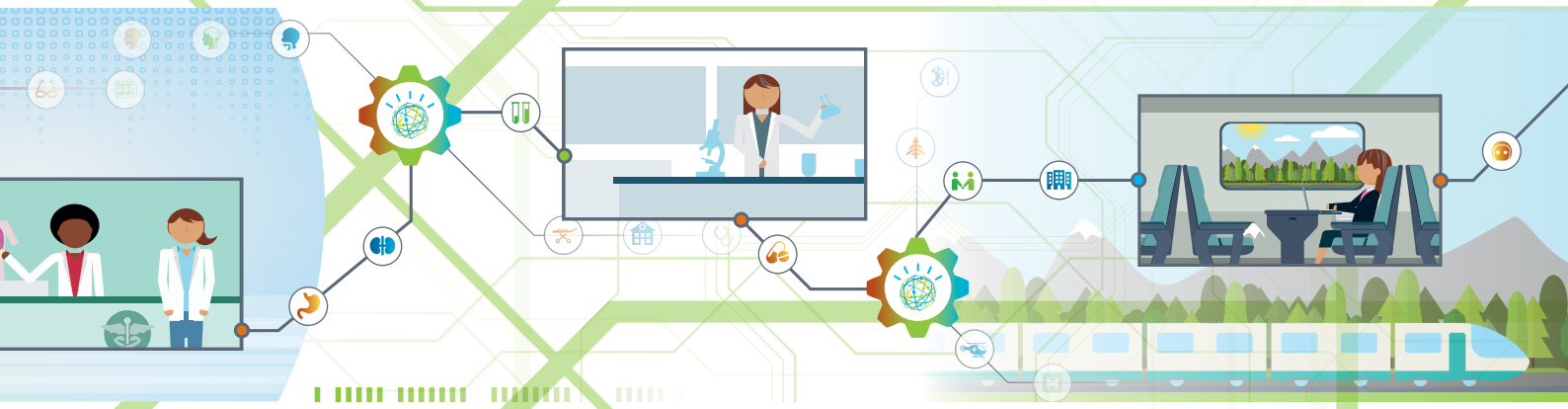
"While the promise of data-driven decision making is at the heart of enabling personalised education, it is vital that we distinguish the narrow uses of personal data from the broader uses for anonymised data. Being clear about this will lay the foundations for all the benefits that cognitive systems can bring."

Katharine Frase, Vice President, IBM Watson Education Business Development.

How do we see the journey from curriculum to career with cognitive systems?

Education as an industry, and the educational professionals within it, are being challenged by the storms of digital disruption to prove their relevance, to maximise value for stakeholders and find ways to reinvent. Educators will need to evolve by embracing cognitive systems to deliver personalised learning in order to drive improved outcomes for all.

The 21st-century learner will demand and deserve no less.



About the authors

Mike King is the worldwide leader for the IBM Education Industry with responsibility for strategy, marketing and sales across schools and higher education. Mike can be contacted on LinkedIn and at mdking@us.ibm.com

Richard Cave is a Principal with IBM Market Development and Insights. He conducts primary research and develops insight into emerging business and technology trends for forward thinkers. Richard can be contacted on LinkedIn and at richard_cave@uk.ibm.com

Mike Foden is a Consultant with IBM Market Development and Insights who has 20 years' experience in market analysis across IT, retail and consumer behaviour. He currently specialises in emerging and strategic business and technology topics. Mike can be contacted on LinkedIn and at mike_foden@uk.ibm.com

Matthew Stent leads IBM's Market Development & Insights Digital Horizons team in Europe and has a long-held passion for championing market intelligence and insights within IBM. His past fields of expertise are broad, covering a variety of industries, geographic regions and technologies. Matthew can be contacted on Twitter @mjstent and at stent@se.ibm.com.

Key contributors

Chalapathy Neti
Katharine Frase
Madalina Irimia
Raluca Dode
Satya Nitta

IBM Corporation
PO Box 41
North Harbour
Portsmouth
Hampshire
PO6 3AU

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