IBM Education Solutions on the Cloud

Creating success for students, institutions and economies
Industry background

Education plays a critical role in the development of individual and societal success. In recent years, a number of business, technological and societal factors have resulted in major transformational industry trends. In fact, we have identified five education ecosystem trends that are forcing institutions and individuals worldwide to re-invent methods, structures and organizations:

- **Technology immersion**: Digitization of educational content, proliferation of personal devices, and online delivery for both institutional and self-learning through mechanisms such as Massive Open Online Courses (MOOCs).
- **Personalized learning paths**: Expectation that personalized education pathways can be created or adapted to suit individual needs and goals, just as the consumer retail experience can be tailored to specific tastes and preferences.
- **Knowledge skills**: The disaggregation of education from large blocks of time or content to skill-based increments delivered by a variety of providers. A common first step is mixing the use of online and in-class content and pedagogy often described as blended learning.

- **Economic alignment**: The desire to tie the needs of employers more tightly to the educational curriculum, including the creation of hands-on internships to enhance on-the-job training by employers and teaching broad skills that enable lifelong learning. Governments are requiring proof of student outcomes (scores, graduation rates, employment), often tied to funding for the institutions.
- **Globalization**: The expectation that educational institutions play an important role in regional competitiveness as sources and hosts of innovation and are accountable to deliver value and satisfactory outcomes.

These trends are challenging existing models in primary, secondary and higher education. In primary and secondary education, the array of possible content and the desire for outcome measures can feel overwhelming to the classroom teacher. In higher education, the rise of MOOCs and other on-line course materials are challenging the role of the traditional college or university. Digital content can and should drive a change to pedagogy—from lectures to discussions, from lecturer to coach. Changing pedagogy requires changes in how faculty are trained and supported, how facilities are built and configured, and how certification is granted. As such, there is increased importance for a clear IT strategy and policy within an educational institution.

The importance of education to economic development and the budget pressures felt by governments, institutions and families around the world are driving a trend toward policy decisions at a city, state or even national level for public institutions. Curricula and measurement decisions are no longer a purely local school decision. Public-private partnerships to identify skills that will lead to employment are also on the rise. One such example is the Pathways in Technology Early College High Schools (P-TECH) program, in which IBM initially sponsored and mentored a six-year IT-focused curriculum in a Brooklyn, New York, high school. The highly successful program has now been replicated beyond IT curricula in three schools across New York City, with another 16 planned across New York State and four in Chicago.
Education transformation: The path to personalized learning
As these trends are now widely understood and accepted, countries around the world are transforming their education systems to respond. While the rate of transformation may vary from one region to another, educational entities are all driven by the ever-increasing adoption of digital content, platforms and devices by learners, educators and administrators, leading to the emergence of big data in education. When harnessed through analytics, data can unlock deep insights to transform the approach to pedagogy and learning. Availability of data from many sources about a learner’s experience and performance should enable personalized learning pathways. Deep insights about a learner’s strengths, weaknesses, styles and preferences can propel each learner on a unique path of discovery and knowledge, guiding him or her toward academic and professional success.

While personalized learning may be a common end goal, the major players in the ecosystem understandably emphasize their content, device or application as the starting point. This fragmented approach leaves educational institutions to integrate the pieces, challenging their resources and skills. Often this forces an institution to move its student data, learning content or both whenever a major application has to be changed or a device becomes obsolete, which is an unfortunate and unnecessary waste of time and skilled resources.

There is another, better way. Using a data-centric/content-centric approach with standards-compliant interfaces, a single view of a student across the different systems within an institution can be created, which enables the analytics that are intrinsic to “personalized education.” IBM Education Solutions on the Cloud allow schools to choose content, devices and applications from many sources in a “plug and play” integration. Automated content analytics, including deeper attributes of consumability and applicability as well as concept tagging, along with sophisticated learner modeling, enable better recommendations and decision support for the teacher, advisor and learner. As we have seen in other industries, this process of “getting the data under control” can be the basic building block needed by many clients, particularly in growth economies.

IBM has played a leading role in educational IT for over 70 years, supporting educators, educational institutions and students with hardware, software, collaboration and support, including the delivery of more than 40,000 courses across 57 countries on 6 continents. As a major employer, IBM also trains and educates its global workforce — and so we see these same trends ourselves. With deep capabilities in big data and analytics, as well as industry leadership in social, mobile and cloud, IBM is in a unique position to drive the transformation of the education industry in the coming decade.

Let’s look at three component pieces necessary to do this — smart instructional content, longitudinal student data and human engagement.

Smart instructional content
Education has always been grounded in the presentation of learning/instructional content to facilitate the transfer of facts, skills and insights. This transmission of knowledge has evolved from primarily oral and experiential to include a much larger component of written materials, particularly the textbook and notebook. The rise of video, on-line and digital content and the proliferation of platforms and devices to consume content open up two important opportunities: 1) the chance to move to “blended learning,” where the push of facts can be done online prior to class and the time in class is spent on human-based activities like synthesis, teamwork, etc. and 2) the ability to deeply analyze the content materials not just for key words, but for readability, learning style matching, complexity, interactivity and standards compliance. Such analysis can be conducted not only on the institution’s content, but all the content that is out there, including published, Web, open, teacher created and student created.
Human engagement

Both the teacher and the student need to be engaged in the use of data, prediction and intervention to reach the desired outcomes. Technology that sits on a shelf or distracts from the core task of teaching and learning will not be used, nor will it be helpful. This implies that the system must provide actionable insights—insights with enough specificity to enable action in a time frame that can affect the desired outcome and insights that fit into the normal workflow of a teacher, administrator or student.

Today, most analytics projects simply describe the current state: using administrative and sometimes learning data, the systems identify students who are underperforming or performing differently than other students. At most, they might employ predictive capabilities to identify students who are at risk with respect to some key educational outcomes. This reporting and identification allow schools to intervene earlier with students, but the interventions are largely based on existing practices and not tailored to the individual. More needs to be done. Identifying students at risk based on administrative data or last year’s tests is simple. However, knowing what to do about these findings and whether the interventions really worked is neither simple nor prevalent today.

Educators need to predict the trajectory of a particular student well ahead of negative data, or as a consequence of intervention, so that positive or negative effects can be rapidly identified. Specific actions should be recommended for the student, administrator or teacher, and the effects of the intervention must be tracked to improve future predictions. Education solutions must automate the collection of the intervention and response data, so as to not add to the time burdens of teachers. And they must optimize the set of interventions for affordability, available time in the classroom and other constraints.

Longitudinal student data

Education has many parallels to the healthcare industry (doctor-educator, patient-learner, treatment-intervention). In healthcare, we have seen that longitudinal health record data can be used to provide decision support to doctors and nurses in the areas of diagnosis, treatment and chronic disease management. Similarity analytics across the case records of hundreds of historical patients can identify the cohort that is most like the current patient to create evidence-based recommendations for the best options for this particular patient. In healthcare, these techniques can lead to better health outcomes for the patients. We are convinced that the same can be done in education, putting personalized learning based on student capability insights within reach.

Underpinning all of these approaches is the ability to do similarity analysis, to identify cohorts of historical students to provide context to the current students. It is vital that this similarity analysis be done based on the data, rather than fit to a preconceived model, as often the characteristics that make students similar are not the obvious things or even school-related factors. This means that data on attendance, behavior, course enrollment, academic performance, demographic indicators and so on should be analyzed to derive student similarity measures. It also means, however, that activity data involving a student, such as content interaction patterns, social and work-related interactions with other learners and educators, etc., should also be captured and analyzed because analysis of such “data-in-motion” often provides rich insights into learning/cognitive styles and preferences.
Ultimately, a rich, evidence-based set of “best advice for this individual and this situation” would result in a decision-support model. These techniques and their effectiveness have been demonstrated in both healthcare and retail use cases and now need to be piloted in educational settings. While some actions will be administrative in nature, most have to include educational content recommendations, relying on the deep and detailed content analytics described above.

Finally, a word or two about the underlying infrastructure and the surrounding ecosystem: These systems must have security and identity protection built into their foundations. This cannot be over-stated. Policy and technology protection for individuals should be a primary system design consideration, not a feature to be added later.

We believe that cloud delivery is essential for the success of these techniques in education. Cloud increases access to the necessary capabilities for school systems around the globe, minimizing the burden on capital and IT skills within a given institution. Cloud also enables the sharing of best practices, content and the patterns of successful intervention between schools in a district or districts in a province. And as with all data-driven systems, more data from more sources can result in deeper insights.

These educational IT systems must also be built with open, industry-relevant interfaces. Providing the best content, visualization, engagement and choices to parents, students, teachers and administrators requires a vibrant ecosystem of application, software and services creators. Open standards enable the easy integration and adaptation of all the ecosystem can create.

Each year IBM identifies a handful of technology and business trends that position an industry for IT-driven transformation. In 2012, one of these highlighted areas was education, for all the reasons already discussed. In light of this transformation need and opportunity, IBM Research has invested in creating and piloting robust middleware and differentiating assets for personalized learning, now being integrated into a comprehensive solution. This solution is grounded in proven commercial technologies from IBM in information management, content analytics, predictive and prescriptive analytics, workflow management, collaboration and visualization. We are adding capabilities specific to personalized education and outcomes, and building toward the promise of cognitive systems (systems that learn, adapt and improve over time, rather than being programmed to a static set of responses). We refer to the roadmap and framework solution as IBM Education Solutions on the Cloud.

IBM Education Solutions on the Cloud
The IBM Education Solutions on the Cloud framework instantiates our point of view regarding personalized learning and the future of education—which is that a framework reliant on industry standard interfaces and grounded in data and content management provides the consistency, stability, security and adaptability needed to transform the world of education. The core components of this approach are:

1. Student Information Hub (SIH), inclusive of both the static/structured administrative data about a student and the dynamic interaction data about a student’s activities. The dynamic portion acknowledges that the necessary data to be collected may change over time, and we rely on a flexible data capture model rather than a fixed pre-defined data schema.
2. Learning Content Hub (LCH) that supports deep analytics across many sources of content, including automated meta-tagging of concepts, alignment to curricular standards, and assessment of aspects such as readability and complexity.

3. Longitudinal data/population analytics and machine learning methods on student and content data to discover and articulate best practices for a particular cohort of learners, delivered through meaningful visualizations to fit the workflow of a teacher, advisor or learner.

4. A platform that includes security and authentication, mobile device management, change management and delivery to mobile devices on the cloud.

The data-centric architecture allows an institution to leverage its existing data about students, along with core applications such as a student information system, assessment data and digital instructional resources. It can be a back-end engine designed to work through a district’s learning management system or provide a portal that educators can use to access and use the resources available. Figure 1 provides an overview of the IBM Education Solutions on the Cloud architecture solution framework.

In the cases where a network of schools across one or more regions seeks to pool its experiences, Learning Content Hub can operate from a cloud, which means the informally created content is also shared.

---

**Figure 1**: IBM Education Solutions on the Cloud.
In cases where harvesting the experiences of the largest body of students continuously as learning takes place is desired, Student Information Hub can also run in the cloud or in some kind of controlled federation. By scaling the amount of data visible to the analytics in the system, relatively nuanced distinctions in best learning paths that apply to relatively small sets of learners can still be detected.

Let's look at a few compelling use cases to illustrate how the IBM Education Solutions on the Cloud components can work together to promote student and institutional success.

**Personalized learning pathways**

There are ample examples of the importance of risk identification in enabling efficient and effective remediation or intervention. Improvements in overall student retention, graduation, performance and employability are central to economic vitality in all parts of the world. Today, there are a number of examples where administrative data or assessment scores are used to identify students at risk. Positive results have been achieved simply by knowing on whom to focus early enough to make a difference. In most cases, however, the actual interventions were not personalized and did not reach into the content itself for best match to needs or learning styles.

**Primary/secondary school**

As an example, consider how IBM Education Solutions on the Cloud could support a secondary-level math teacher in identifying personalized approaches for at-risk students: In this example, the school system has digitized its student information and has started moving toward digital content and delivery, including homework and assessment, through the use of personal mobile devices. These underpinnings allow for deep content analytics, integration of information about a given student, and pattern discovery from population analytics on historical students.

The teacher logs on to her case management system and asks to see information about her eighth-grade math class. She sees a visual representation of her students through a number of lenses, including their risk profiles for doing poorly in the class. She can select a particular student to learn more. The analytics provide her with the insight that this particular student does well with some concepts in the class but seems to struggle every time a particular concept (e.g., “transformations”) is included in coursework or tests. She also learns that this student has reading and language challenges in other classes (something she might not know in the normal departmental structure of schools). She asks the system for suggestions about additional content and is shown very detailed analysis across several different sources (several publishers, her own materials or materials from other local teachers) rated for applicability to the transformations but also scored for readability, density of concepts and success when historically used with similar students. The teacher chooses which pieces of additional content to highlight and will also be able to monitor the student’s engagement and success with this new content. Not only does this support the teacher in personalizing instruction in a practical way, it also enables her to reach this student without slowing down the rest of the class or exposing the student to scrutiny by peers.

Note that while we have focused on an at-risk student above, personalized learning is necessary for all students, including high performers who require differentiated content and instructions to keep them motivated and engaged. By focusing on student similarity and cohort analysis and by analyzing each piece of learning content along many different dimensions to suit different categories of learners, IBM Education Solutions on the Cloud help ensure all learners receive personalized recommendations and guidance.
It is vital that the data, analytics and intervention technologies fit into a teacher's daily workflow and available time. We have focused on this aspect by partnering with teachers and educational professionals and by piloting the solutions in real classrooms to help ensure they can be practically adopted. The platform includes a workflow engine that allows teachers to create intervention plans with associated deadlines and assign those activities to a student. The workflow aspect of the system assures that all stakeholders in the intervention are made aware of the required actions and that those actions are tracked and monitored to assure completion. The IBM Education Solutions on the Cloud platform captures data regarding the interventions and uses that data to improve subsequent interventions.

An excellent example of personalized education can be found in the Gwinnett County Public Schools (GCPS). The district is working with IBM on a pioneering research and development relationship that combines predictive modeling and content analytics with traditional classroom learning. The Personalized Education Through Analytics on Learning Systems (PETALS) project leverages big data, deep analytics and cognitive technologies to help develop personalized education and learning pathways for students (see Figure 2).

Figure 2: IBM Education Solutions on the Cloud: Pilot at Gwinnett County Public Schools, Atlanta, Georgia.
Higher education

Higher education institutions are challenged to deliver differentiated value to students across their whole experience (from recruiting to enrolling to graduation and employment), as well as improve student performance while enrolled. The use of social media, transparent communications, mobile enablement and interactive content has demonstrated substantial benefits to students as well as institutions.

Obviously, these older students are more personally responsible for requesting assistance or persevering through a difficult topic. However, several recent studies have shown that analyzing a student's study habits and class performance and enabling faculty to encourage the student directly can lead to significant improvements in course performance.

The educators in these studies did not actually make personal recommendations; the students were simply encouraged to use the existing course materials or on-campus tutoring assistance. Imagine the potential improvements if personally relevant content were recommended based on learning style.

Career pathways/employability

Historically, it has been hard for businesses to forecast their skill requirements with enough precision and lead time for educational institutions to align to those needs. Without this visibility, it is difficult for parents, teachers or counselors to give students useful advice on employable skills. However, analytic techniques now exist to help businesses include human resources and skills in their strategic planning and to identify what the real skill characteristics will be. When analytics are applied to the employer end of the spectrum, they can help identify what skills businesses will need in a few years’ time, thereby providing enough time for educational institutions to align their curricula to career paths.

There are well publicized descriptions about the mismatch between potential employees entering the workforce and the employment opportunities available. Graduates of high school and university are finding it difficult to get jobs, while employers complain about the mismatch between the jobs they have available and the skills and talents of applicants.

According to a Forbes article, there are four million U.S. jobs waiting to be filled, and “American businesses could be filling more of those jobs—if they better utilized technology.” And, according to a January 2014 report, 27 percent of employers in Europe have left “entry-level” jobs unfilled in the last year because they could not find workers with the necessary skills.

There are multiple reasons for these employability issues. For example, lack of a high-school education dramatically reduces employability options. In the United States alone, 8,300 students drop out of high school every day. But even college graduates are completing school with skills that are mismatched to employment opportunities. Some of the issues contributing to this are highlighted below:

1. Career opportunities in the twenty-first century require more precise skills than a general-purpose educational background provides. Employers don’t have the time or financial resources to provide additional training to general graduates.
2. Students are not certain about which careers will be promising at the time of their graduation.
3. When students are aware of promising careers, they are not savvy about how to best prepare for them.
4. Secondary schools and higher education leaders are not always aware of rapidly changing career trends and what programs or certificates they should offer to best prepare students.
5. Credentials are not standardized across institutions, making it harder for employers to evaluate the suitability of a particular graduate for a particular job function.
6. When secondary schools and higher education are aware of future career opportunities, they often are not well equipped to determine how to best prepare a particular student for these roles for facile in changing their own curricula.
The IBM Education Solutions on the Cloud framework addresses a number of these issues. The Career Cluster Hub aggregates growing career opportunities over a future time window, using big data gleaned from the media, job postings, Department of Labor and other Web sources. The skills and talents associated with these career opportunities are identified based on other successful employees in these job spaces. Statistical processing identifies the number of people moving into some of these areas, as well as likely opportunities in a given region and industry. Recommendations are provided to individuals, based on their own propensities, skills and talents as gleaned from the Student Information Hub. Other employees that have successfully transitioned to these careers can be analyzed with respect to their own experiences and training. A particular student and aspiring employee can be mapped to an already successful employee with similar learning styles in this target space, and academic and internship opportunities can be recommended accordingly.

**Adopting IBM Education Solutions on the Cloud**

For any of these technologies to be adopted in the classroom, they have to fit into the available time, resources and work pattern of the teacher. In the personalized learning pathways example, a case management paradigm was used to provide convenient decision support for the teacher. However, there are other aspects to this as well. Existing teachers may need training to become comfortable with the role of technology in the classroom. New teachers and those studying to become teachers need different course materials from past generations. And in the developing world, where lack of sufficient numbers of skilled teachers is the main inhibitor to wider access to education, technology can help bridge the gap.

In many countries across Asia, Latin America and Africa, the demand for quality education is exploding, but substantial challenges exist around the physical, communications and human infrastructure needed to deliver quality education. Schools and education companies are improving the quality of classroom learning content through digital means, and many governments aspire to have digital content on mobile devices for all students. As such initiatives get embedded within education systems, IBM Education Solutions on the Cloud can create an affordable sense of personal engagement within the reality of high student-to-teacher ratios.

**Getting started**

While the examples cited create a vision for the future, how does an institution get started?

We believe there is a logical pathway, beginning with enabling digital content in the classroom, then enabling the student to benefit from access to digital resources and enabling mobile device delivery for anywhere learning. These first three steps enable the data collection, integration and analysis needed to unlock personalized learning, leading to better educational outcomes and employment prospects.

We outline a number of the critical steps below:

- **Maximize value by:**
  - Integrating student data for a single view of the student
  - Analyzing education performance
  - Identifying student and organizational risk.

- **Analyze patterns to:**
  - Capture best practices
  - Support teachers.

- **Enable better outcomes, including actionable insights for teachers, administrators and students, through:**
  - Instructional intervention
  - Coordination of learning services
  - Personal learning environment.
As with any enterprise, the operational “back office” of education can also benefit from streamlining, automation, integrated data management, analytics and adoption of cloud computing. Often it is the administrative systems that first need to be transformed, as was the experience in Gwinnett County, to both enable and afford the investments in the learning and teaching processes.

**Conclusion**
At IBM, we believe that in the next five years, it will become a practical reality to have affordable tailored advice for both students and teachers, build on students’ strengths and help them work on their individual skill gaps, and connect students’ talents and interests with likely employment opportunities. Doing this requires smart content and deep analytics to create the insights that will move education from assembly-line models of classroom instruction to an affordable personalized environment that motivates and engages learners at all levels.

This classroom of the future will enable a partnership of educators, parents and students to learn about each student using longitudinal data. It will provide an environment of experiential learning, helping students learn what they want at the pace they need, as opposed to an arbitrary curriculum. The underlying systems will provide “decision support” for teachers to identify students who are most at risk, recognize their derailment factors and deliver insights for tailored interventions to overcome each student’s challenges.

**For more information**
To learn more about IBM solutions for education, please contact your IBM representative or visit ibm.com/industries/education

**Why IBM?**
IBM has more than sixty years of experience helping education clients around the world improve the efficiency and effectiveness of operations through the application of IT. IBM has the full range of support our education clients need, from consulting services to help set institutional strategy, through systems, software, analytics and cloud delivery for implementation and operations.

**About the author**
Katharine Frase is Vice President and Chief Technology Officer for IBM Public Sector, helping clients in education and other industries transform their businesses through technology.
References


6 Ibid.


8 “Open Academic Analytics Initiative (OAAI).” Marist College, Open Academic Analytics Initiative. https://confluence.sakaiproject.org/pages/viewpage.action?pageId=75671025

