Applying the cloud in education

An innovative approach to IT
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The world of education and training has always embraced new teaching methods and tools, albeit at different rates of take-up. Since the arrival of the computer—and later the internet—in classrooms, administration departments and our daily lives, schools (in the widest sense of the term) have been in a race to keep up with society’s requirements. In this regard, technological enthusiasm represents an enormous challenge that is made even more acute by budget restrictions and the vagaries common to public procurement contracts.

The purpose of this document is to show how a recent technological development could lighten, in some regards, the burdens of equipment, management and new teaching methods that weigh so heavily on the shoulders of educationalists.

Cloud-type IT solutions (designed and provided in the form of optional, tailored services, with operators and teaching establishments pooling their resources) potentially offer a series of benefits:

- lower costs, by sharing equipment and solutions, and through the “consumption” of resources on demand (which allows invoicing for actual usage);
- a reduction in the technical support provided by each establishment;
- faster progression of solutions, thereby avoiding the kind of investments that “restrict” an establishment’s IT system for a relatively long period of time; and
- the promotion of exchanges and participative or collaborative methods – between establishments, and among teachers and students.

This document presents the main principles and potentials of the cloud, as applied to the world of education. It also uses examples taken from international sources (see section IV) to illustrate some of the routes that might be taken at a regional level to implement cloud technology. A series of existing local initiatives, of which we have taken just three examples here (see section V), also indicates that the key concepts behind the cloud (which, to some extent, are only an extension of current principles) have already been adopted, and therefore already meet the needs and wishes of those involved in education.

Drawing on these ideas to initiate projects that could be run by local education providers would enable them to take a valuable step towards matching their own expectations with available tools. A number of theme-based concepts (“intelligent” classrooms, virtual lecture theatres, teaching analyses, new professional models, etc.) are detailed in this document by way of examples (see Section VI). These could be used as a common thread in models for future initiatives and developments that would be run by local education providers which have already adopted these concepts, or by those that intend following this path by making the most of their expertise to benefit others.
Introduction – Rethinking ICT to reinvent education

The challenges of education

While budgets and resources remain under pressure, the education sector finds itself confronted with the growing challenges presented by technology (in fact, this is both an opportunity and a challenge) as well as by fundamental changes in society. In particular, these are:

- the increasing speed of innovation (pace of renewal) in information technologies that no longer allows teaching establishments to keep up with the pace of development and stay in line with day-to-day technological reality, even though it is vital that pupils and students are prepared for IT in the best possible way. This means that the burden of investments in hardware would benefit from being shared;
- the “consumerization” of IT, which places new tools in the hands of students. These tools change our relationship with knowledge and need to be incorporated into the education process; and
- the emergence of generations of “digital natives” who have a perception of life in society and relationships with others that are influenced to a large extent by digital tools and types of behavior that are fundamentally different from those experienced by the generations before them.

These phenomena are generating a demand from users to be able to support and incorporate the new types of devices used by schoolchildren, students and teachers (portable PCs, smartphones, touchscreen tablets, e-readers, etc.) as part of the teaching establishment’s ICT infrastructure. There is even a need to include users’ own information sites – like portals, blogs and wikis – which they themselves may have created.

Any delay for education in keeping up with technological innovation is likely to make contact between the world of education and society even more difficult, as stressed by the AWT (Wallonia Telecommunications Agency) in its ICT Barometer.

More than ever, it is a question of adjusting the context of education to meet the expectations of students better and to fall in line with the new reality of the world of business and the digital society.

Pupils, students and teachers alike need tools that are more versatile and that can adapt to new developments. The main effect of the advent of new systems (including mobile ones) has been to open up the teaching and learning space, which is now no longer limited merely to the confines of education establishments.

Mobility is both a growing reality and a requirement for students and teachers. Both now rely more and more on IT tools to prepare or review classes and access resources and knowledge in locations other than the classroom.

The pace of learning has shaken off the shackles of the “8am to 4pm” school-day cycle. Increasingly, school pupils and students have come to expect an educational environment that allows them to learn at their own pace.

Added to that is the “social” dimension: Increasing numbers of students of all ages and education levels are now seeking to combine the learning dimension with the community dimension (e.g., through social networks).

More so than previous generations, Generation Z (i.e., those children born in the 21st century) sees life through digital tools and devices – internet, mobiles, smartphones, chat tools, blogs, social networks, video sharing, and so on. It is their primary point of reference, their main tool for communication, for relationships and even for citizenship. This Generation Z is sometimes dubbed Generation C (Communication, Collaboration, Connection, and Creativity).

The concepts of “just-in-time learning”, “community learning” and “found learning” are gaining ground and require a
new approach, and a new role for teachers. Generation Z is immersed in an environment where collaboration, exchanges between peers and spontaneous, ad hoc learning in communities and networks are intrinsic. Surfing the Net, looking for new encounters, discoveries and experiences has become virtually “first nature”. Learning by personal or group experience is a new way of developing one’s self and one’s knowledge. Using nothing but yesterday’s teaching tools can only upset stability and appear artificial to people learning today. In fact, on a more fundamental level, it actually deprives them of the tools they need most to master the skills that they will require both in today’s world and tomorrow’s.

Collaborative work and social participation are already a reality in society in general. Society, therefore, needs to take possession of learning spaces, not only in the classroom or between pupils and students in the same year, but also between classes and schools in other locations (near or far).

So high are the expectations of the younger generations and all those whose job it is to bring them proper learning content, that they are entitled to demand these developments in education.

The principles of the cloud

From a purely operational and technical point of view, cloud computing is a model for deploying IT resources and capabilities that seeks to minimize the implementation and management load for the user organization. The principle of the cloud is to make available a set of IT resources (systems, applications and/or data) in the form of services that users can call on and consume “on-demand” via the internet or an intranet/extranet, and only pay for their actual consumption.

Because of the very concepts that determine what it is, the cloud is much more than just a technological phenomenon and more than an nth generation computer system (after mainframes, servers, PCs for all, etc.). The principle of the cloud has entered day-to-day practices – and will continue to penetrate them more and more. It delivers an in-depth change to the relationship that users, service-providers, businesses and economic or social players of every kind have with the IT resources that underpin what they do and the way in which they carry out their processes and activities.

The principle of the cloud also corresponds perfectly with a stage in the development of society in which relationships between people, generating knowledge, establishing collaboration and even searching for direction are expressed and organized in meshes that are virtual, spontaneous, self-restructuring, random and constantly evolving.

Missing out on the cloud is to deprive ourselves of this flexibility to adapt to, and consume, the abundant resources that surround us.

Cloud computing brings together infrastructures, software, processes and a range of services. To be called “cloud”, a solution has to meet a number of characteristics:

- the resource and its content must be available on a self-service, on-demand basis;
- the service must be accessible from everywhere;
- it must enable sharing and the exchange of resources;
- it should provide flexibility in the infrastructure, allowing for rapid expansion, resizing, and the adjustment of capabilities and performance based on changes in need or demand; and
- it should provide the ability to “measure” the service – enabling the monitoring of “consumption” so that usage can be billed.

See Annexe A for a more technical description of the possible ways the cloud principle can be implemented.
What the cloud promises for education

It is true that the range of resources and services available via the cloud, whether they concern the IT infrastructure or the solutions they enable to be implemented, involves the introduction of new processes. In addition, the cloud brings many benefits, of which we provide a series of examples below.

Savings
The cloud promotes the more efficient use of IT resources, in particular through:

- a reduction in costs through sharing IT equipment, centralized on a cloud platform (with the virtualization of machines reducing the number of systems required); this delivers economies of scale (when there is sharing between various sites) and obviates the need for costly local infrastructures that are under- or over-sized, or not used to their maximum potential (typically, 50-90% of server capacity is unused);
- a reduction in the cost of provision (software licences, management skills, physical security of premises housing servers);
- a reduction in the size and complexity of the number of machines and programs to be installed at each site, and hence the cost of licences and maintenance is less;
- a dramatic decrease in the number of applications to be installed and rolled out to the computers at each site (access is carried out remotely on a centralized application in the cloud for an unlimited number of users);
- the billing of services based on the actual use of resources (pay-per-use);
- human resource savings (technical staff required to manage in-house machines); and
- freeing up Capex budgets (the cloud involves the Opex [operational expenditure] model)

Upgrades guaranteed

The cloud leads to improved “anti-obsolescence” insurance for IT solutions because it is able to cope better with the increasingly rapid pace of change in technologies.

It also enables all documents – projects, homework, syllabuses, and collaborative exercises, for example – to be updated in a centralized and systematic manner and to be modified consistently at a single central point. This helps ensure that these documents are appropriate and relevant and that all the information they contain is identical for all users.

Flexibility
One of the main benefits of cloud-based IT and teaching resources is that they help prevent the barriers to progress that come from making individual investments in equipment (because individual investments must, first and foremost, be made cost-effective before any upgrade or replacement can be envisaged). The centralized infrastructures in the cloud use various technologies (e.g., virtualization and modularity of component parts) that promote flexibility, including:

- speed of adjusting to change: Centralizing and standardizing the available resources enables faster upgrades in line with technological progress and/or changes to demand and requirements;
- smooth adjustment to ICT resources (e.g., servers, storage space, calculating power, application authorities, content) and how they are made available, thanks to the flexibility of the infrastructure, and the ease of accessing resources based on needs (since, with cloud-based ICT, a new version of the application or any application software can be more easily distributed to users);
- flexibility in implementing teaching content – including, for personalized learning, a customized teaching process that meets the needs and specific difficulties of each student (or each profile of student); students are then able to draw from
the whole of the content available, as well as find the
information and tools they are looking for that are appropri-
ate to their stage of education;
• flexibility in terms of the number of machines needed: Cloud
architecture can potentially support every type of client
hardware and application (albeit with a number of excep-
tions, depending on the service-provider);
• self-service potential for students, teachers and education
establishments; and
• flexibility of learning, giving easy access to courses and
content at any time, any place; options to learn outside the
school itself, as well as outside of the school calendar (holi-
days, ongoing learning after-school/postgraduate training).

**Effectiveness**
The method of deployment that the cloud makes possible for
IT resources can also promote more dynamic exchanges and
participation between teachers, pupils and students, their social
network and parents.

The methods available are more numerous and can lead to
more productive and effective learning for the student (a rise in
their level of understanding and achievement within their stage
of education, increased chance of success, gaining a clearer
view of the realities of their future working life, etc.).

In terms of teachers’ and resource administration, the cloud
model encourages the pooling and implementation of good
management practices.

**Sharing**
Skills, good practices, applications, teaching content and
infrastructures can be pooled and shared to avoid each estab-
lishment duplicating resources that exist elsewhere.

Sharing equipment also has the effect of harmonizing resourc-
es, making it easier to support them, and avoiding the prob-
lems of incompatibility or difficult integration between various
tools and systems (including within the same establishment).

Pooling quality teaching content also brings the prospect of
removing and avoiding educational inequalities and the issue of
“poorly performing” or “second-rate” schools. It promises
fairer access to educational and learning resources. It is part of
the solution for bridging the digital divide, promoting a new
way of making education more accessible and, ultimately,
avoiding highlighting digital inequalities rather than reducing
them.
Major trends

To a certain extent, changes in the world of education follow, and are influenced by, the major trends seen in society in the broader sense – immediacy; access to an increasingly large and varied mass of both information and knowledge; the concept of being “always connected”; the traceability of the acts and deeds of every individual; the importance of performance; the centrality of socialization and collaboration; and so on.

As a result, the education world needs to bring a number of issues under control. For example:

Access to resources using a whole range of different technologies, including a large number of mobile devices.

Personalized, individualized learning processes. This involves a new approach from teachers, who also have to learn to master these new tools and new flexibility they provide so that they can adjust their behavior and habits and move the way they supervise and guide students into the new era. The rigid walls of the classroom are giving way to the random, moving shape of the internet, which makes it possible to monitor students at any time of the day; have real-time dialogue with them about a piece of homework or assignment that they are working on at home; send corrections or comments (e.g., by SMS, e-mail, or instant messaging) while one or the other is on the way home; conduct scientific experiments in a virtual lab without everyone necessarily being present in the same room; and so on.

Redirection of “professional” processes now focused on the success of each individual student.

Accurate evaluation of individual performance – both of the student and the school.

Predictive analysis and dynamic development of the educational context designed to reduce the risk of failure or dropping out.

Gathering information and applying analytical diagrams make it possible to assess the student’s progress on a day-to-day basis and enables quick and easy adjustments to the teaching material (e.g., the type of exercises being used) and the method of supervision and guidance used. Based on past statistical data, it becomes possible to predict failure and identify the signs of going off the rails or becoming demotivated at school so that the teacher is immediately aware and can take action. All of this is made possible without having to wait until the end of the year and the merciless verdict of exam failure.

Acquisition of new skills and knowledge
The current change in teaching context (internet versus the blackboard) in itself implies a new relationship with knowledge – knowledge that is now easier to access and can be used differently.

There is a duality between teaching the individual and running flexible learning communities, because virtual communities operate in different ways, depending on the area of learning and the people involved. This means that pupils can be in the same classroom, but operating in virtual networks that are very different from each other.

New profiles
Teachers must be capable of:
• guiding students in the new “time-space” that is created;
• guiding and advising them in their various methods of learning (including via social networks, online discover, etc.);
• acting as referees to avoid bad habits (e.g., filtering unsound knowledge gleaned from the internet or from “friends” on social networks); and
• basing their teaching on collaboration between students and promoting their more energetic participation in classes, something that is fuelled by unencumbered access to information.
As we will see in the sections that follow, the “transfer” of infrastructures and solutions to the cloud opens the door to many different scenarios. We have chosen four examples taken from international sources. The first three each concern a specific stage of education (secondary, university, or research). This does not exclude their relevance for other stages in education too, however, which can also take advantage of the principles implemented.

**Case 1: Shared ENT (Digital Work Space)**

*Environment: Secondary school*

In the Pays de la Loire region, the education authority of the Académie de Nantes, the Regional Council and the General Advisers of the five départements (Loire Atlantique, Maine et Loire, Mayenne, Sarthe and Vendée) have pooled their resources to provide all colleges and high schools in the region with the same *Environnement Numérique de Travail (ENT – Digital Work Space)*. This is called e-lyco. Although shared by all schools, the ENT can be personalized by each of them. Six hundred and eighty five educational establishments (public, private and agricultural), totalling almost one million users, including 321,000 students (the balance being parents, members of staff, etc.), will be connected by 2014.

Examples of the services offered:
- access to marks and results, non-attendance records, teaching content, and the content of previous courses (such as files and graphics);
- class blogs (with space for questions/answers between students and teachers);
- a forum in which students can work remotely with their classmates;
- a space dedicated to parents, who are able to access exercise books (showing work done in class, a list of lessons, homework, checks, and so on) so that they can monitor their child’s progress;
- messaging (e-mails between teachers and students); and
- collaborative tools enabling resource people, technicians or experts to share solutions and practices and, by doing so, help develop the platform and speed up the resolution of any problems.

**Aims and benefits**

This project pursues a series of aims, including to energize the involvement of the various people involved in the education process (i.e., pupils, teachers and parents); to enable more effective supervision and education, without the constraints of time or place; and to reduce the risk of dropping out, by including those pupils who are absent or ill (by giving them access to lessons and monitoring).
Case 2: IT resources on demand

Environment: University

North Carolina State University has implemented a Virtual Computing Lab (VCL), a cloud infrastructure that pools IT resources of several sites (servers, storage systems, and software authorities). The VCL enables the pupils from the various primary and secondary schools in the State, as well as the students using the different university campuses to access, a highly developed and up-to-date pool of technical and learning resources wherever they happen to be (including at home).

Depending on the type of need (whether it comes from a teacher, pupil or student) and the corresponding stage of education, the platform makes ad hoc resources available – from simple desktops (virtualized) to virtual laboratories for an entire class (with as many virtual machines as there are students), as well as servers, storage space, and high-performance calculation clusters (for high-power calculating).

Some examples include: access to Alice applications (animated stories in 3D) or MathQuest for primary pupils; access to a virtualized server and sufficient storage space and activation of a physics program by students for their homework; access to statistical applications or mainframe simulators and resources for university students; and, access to HPC resources (high-power calculating) for university researchers.

Each time a service is made available, it is done by creating a session that then obtains the required volume of resources. Once the exercise, class, or simulation has ended, the resources are placed back in the pool, ready to be allocated to other purposes.

Each establishment can access its own “portlet”, complete with personalized menu of its needs, class content, etc.

The VCL cloud is accessible to approximately 250,000 pupils and students. The infrastructure pools some 2,000 physical servers, supporting nearly 5,000 virtual servers and more than 800 software images.

Aims and benefits

Aims: to improve the rate of use of IT resources, reduce the maintenance costs of the infrastructure, provide everyone with access to optimized resources.

Benefits achieved: up to 75% savings on licence costs, 150% increase in the ratio of the number of students/licence; enhanced flexibility; better rate of use of servers; lower investment in desktops (use of thin clients); IT support team reduced to two people.

All pupils, no matter how distant or modest their school, have access to the same learning resources (e.g., videos and interactive 3D animations for studying geography) as their fellow pupils elsewhere in more distinguished and better-funded schools.
Case 3: Central resource reference system for research projects

**Environment: Research**

To enable it to better plan, manage and assess the progress of research projects underway, the College of Pharmacy at the University of Rhode Island has created a **collaborative portal linked to social networking tools**. The aim is to identify more easily, quickly and completely those individuals who would be of value for working on specific projects and identifying the resources (i.e., the skills, the data, and the funding) that each project might benefit from. The basic premise is that the growing volume of data and publications in existence across the world makes it increasingly difficult to find specific or relevant information that might be of interest to researchers. The solution includes a central database (e.g., of registers, identity data about teachers, articles published, theses and dissertations), a collaborative portal, and tools for social networking and content analysis.

Each project leads to the creation of a profile and dedicated webpage that is used as a space for meetings and collaboration with other researchers with identical, similar or complementary profiles and skills.

Based on the profile and description of the project, the system automatically and systematically searches for potential matches and relevant information on the internet – researchers, projects underway, theses, funds available for the disciplines in question, and so on – and collates them and then suggests contacts or collaborations that can be made.

The analysis software (for analyzing the content) and social networking-type tools identify research resources and opportunities (skills, interesting individuals, relevant scientific publications, etc.). The optimization software recommends the allocation of resources (students, professors, grants, etc.) and automatically establishes correlations between grants, researchers, skills, available hardware and resources available.

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**Aims and benefits**

Faster identification of resources (human, financial) wherever they are, contacts with researchers, automatic recommendation service.
Case 4: Collaborative learning

Aims and benefits

Whether it involves social or more conventional collaboration tools, the aim is to promote working independently, to involve the person more dynamically in the process of learning and acquiring knowledge.

Benefits: development of a critical sense, independence and dealing with the working methods and contributions of other students.

Collaborative education and learning makes reference to various principles, such as:

- collaboration between pupils or students to carry out a project;
- use of collaborative technologies for educational purposes; and
- an “active process by which the person learning works to build his or her knowledge; the teacher than plays the role of learning facilitator, while the group is used as a source of information, vehicle for motivation and means of mutual support” (as defined by France Henri and Karin Lundgren-Cayrol, authors of the book *Apprentissage Collaboratif à Distance – Collaborative Distance Learning*).

Social networking tools (Facebook, Twitter, etc.) have their own place in the system. Laurence Juin, a teacher of language, history and geography in a French high school has been experimenting with the potential of these tools for over a year (see: frompennylane.blogspot.fr).

Using Twitter has the effect of opening the classroom up to the outside world: Teachers and parents can follow what the pupils are writing, in micro-blog mode. Exchanges can be structured, by theme for example, and be marked using #tags for subsequent research. The tweets can be used as virtual pathways to documents, texts, websites and so on to gain reactions, proposals, and comments from the network of “followers”. Some teachers use these new media as a collaboration tool for preparing presentations or for exchanging ideas and good teaching practices.
Practical scenarios for "Education 2.0"

The principles associated with cloud computing (centralized and optimized resources, consumables, resources on demand, resources with the ability to evolve, etc.) enable us to revise the way in which education establishments and students are able to use equipment, applications and content.

All around the world, as well as here at home, initiatives are being created to make use of this new method for making resources available.

The way in which Education 2.0 is able to implement these initiatives may take many different forms. As examples, we have selected eight, theme-based scenarios that apply to various contexts, processes and situations. All are based on the reality or the promise of cloud techniques and technologies.

Virtual lecture theatres

Communication and collaboration technologies are bringing down the walls of the classroom, promoting exchanges, group work and inter-school projects. They are also enabling teachers in a different country to teach classes, complete with the required material, to classes locally. Such ICT is also enabling pupils of the same age located in distant towns or countries to share in the experience of the class being taught online.

Platforms and content hosted in the cloud enable teachers to create collaboration spaces or forums where they can interact and invite colleagues to join in, whether they teach the same subjects or not. This enables students to approach topics in a wider context. For example, a parallel or linked discovery made by Greek scientists, could be approached simultaneously by mathematicians and historians.

Labs in the cloud

Using a virtual laboratory, a cloud infrastructure can offer the resources for processing, calculating and simulating that are needed to create a compound, on demand (for a specific period of time and based on capacities sized according to needs). Pupils or students are able to carry out all of the virtual simulations or experiments that they want in it (chemistry, physics, social sciences, economics, etc.), from the simplest to the most complex, provided the required IT resources (calculating power, simulation tools, etc.) are made available to them. This scenario is based on an adaptive system of ICT consumption.

Intelligent classroom

- The availability of resources and applications in the cloud can benefit the quality and effectiveness of teaching at the classroom level. A few examples include:
  - access to courses, syllabuses, documentation and information, regardless of where the student happens to be: in a classroom, in the school’s open spaces, at home, travelling on public transport, or in the library;
  - individual access or by group of pupils to the same learning content, allowing for collaboration;
  - personalized access to the learning resources best suited to the student’s needs, or to his or her learning difficulties, for example, with freedom of choice (or guided by the teacher);
  - opening the teaching resources of one establishment to the pupils and teachers in others so that they can share good practices; and
  - centralizing the results of tests, exams and homework, as well as teachers’ assessments, to provide immediate identification of each student’s difficulties and to place current results in context (e.g., compared with fellow students, as well as with their own personal academic history).
Applying the cloud in education

Scenario 1: personalized supervision
New tools like smartphones, tablets, and the internet now enable students to study, finish a piece of homework and/or consult an e-manual or information website wherever they happen to be – in the classroom, aboard public transport, or at home. Similarly, new assessment tools make it possible to “capture” the actions of the student (websites viewed, type of exercises carried out, quality of the way answers are formulated, etc.) in real-time and to send that information for analysis and evaluation to a central department capable of monitoring progress.

This type of assessment tool, which can be used by the teacher and is accessible to parents, can also enable the pupil’s personal education program to be adjusted, based on results gained on a day-to-day basis.

In the classroom, the teacher can be notified automatically about the various websites that the pupils are visiting for their project. This also enables the teacher to guide the students to more interesting sources of information or advise them about sites they may not have considered before.

Scenario 2: virtualization of desktops
A cloud infrastructure makes it possible to have a group of individual IT resources available that can be sized according to changing needs (for example, the number of pupils per class or per subject). With PC desktops now virtualized, there is no longer a need to buy them in sufficient quantities to equip various classes, as these can be served by more cost-effective thin clients (hardware with fewer functionalities and hence less expensive).

For example, the education network of Pike County Schools (primary and secondary schools) selected the thin client approach. In this remote area of Kentucky, budget restrictions and ageing PCs (which were expensive to replace or repair) were causing problems for the network. There were only 4,000 PCs for 14,000 users; some schools still had PCs that were more than six years old; others had disparate hardware, making it impossible to teach everyone in the same way, and in a manner that was fair for everyone.

The solution involved creating 1,400 virtual desktops (with a single system image instead of the 40 previously used system images), so that the existing PCs could be utilized as display tools. (The applications, storage space, etc., are now available on a remote infrastructure.) All the students now have access, including from home and via mobile devices, to up-to-date, high-performance IT resources and applications (including office or learning software). The teachers are able to monitor and supervise the work and progress of their pupils better – including homework – with everything centralized.

Virtualizing desktops also makes it possible to allow hardware to be mixed in classrooms. This potentially provides the possibility of leaving freedom of choice to each student or to vary the types of “terminal” used based on the subjects being taught and their requirements for resources, content and presentations.

Portal for IWB content
Digital IWBs (interactive whiteboards) are gaining a foothold in both primary and secondary schools. However, schools and teachers are still heavy users of appropriate digital content. Although classes, materials and content may have developed in other countries, they are still not necessarily suited to local teaching programs. Moreover, some of the material offered by certain manufacturers has yet to be approved for teaching by education professionals.
Therefore, teachers using IWBs sometimes resort to content that they have created themselves, occasionally by digitizing existing documents. Sharing this content and developing the input from teachers would have a favourable effect, both on the diversity and quality of the content, as well as on the ability of all schools to access quality content that they have not had the resources to develop themselves. In this regard, creating a reference system of content that remains in the public domain would have the advantage, in the eyes of some observers, of avoiding the pitfalls of using nothing but commercial content (i.e., copyright issues) as well as gaining better approval from education professionals.

**New professional models**

To an increasing extent, new teaching methods – and the digital landscape in which education is operating – are leading to developments in skills and professional models.

Some examples include:

- **collective teaching**, with the virtual presence of several teachers for the same subject;
- creation and **publication** of content by the teaching body – teaching content made available to fellow teachers and any student who has interest, possibly with the teacher or school being paid for the content they develop;
- **(renewed) involvement of parents** in the teaching process and guidance: For example, portals or solutions along the lines of digital work spaces (DSW) may enable parents to follow the academic progress of their children, possibly using comparative data (e.g., the results of students of the same age from other establishments or countries, with individual data made anonymous). The availability of this kind of information (results, non-attendance rates, effectiveness of group work, degree to which online resources are used, etc.) can serve as a springboard for interaction with teachers;

- **personalized teaching**: For example, based on the data gathered during the academic year, the teaching systems can make a dynamic selection of the teaching content that matches the profile of each student. Advances in technology are already heralding a “Web 3.0” that will implement techniques such as ontology and the management of metadata to structure and filter data and knowledge spontaneously;

- **real-time assessment**, using analysis tools capable of monitoring and tracking the activities and educational progress of each student, then sending that information to a central point (or to the teacher’s system) to be analyzed and assessed, and triggering recommendations in real-time. This systematic and regular assessment has the potential to change the nature or purpose of traditional exams and tests; and

- **learning and collaborative teaching** with collaborative applications, tools such as wikis, videoconferencing solutions and interactive whiteboards, as well as social networking tools, are encouraging collaboration between students, even if they are not in the same class (and even if they are thousands of kilometers apart). They are also enabling several teachers to play a part in the same lessons. Collaboration can also be established between pupils, or between students and teachers, outside the classroom. Such social networks could open up teaching to outside contributors, such as a specialist in a subject being studied who might, for example, be a parent or colleague of a parent.

**Intelligent administration**

The demands made on school administrators seem to involve cutting costs, boosting efficiency and the need to support new teaching methods. Each school also needs to position itself in relation to other schools, to put forward its specific features and added values, or to measure up with its counterparts, whether local or not. This means they need effective tools for management, assessing performance and managing resources.
Some of these tools allow for the **analytical monitoring** of both teaching programs and pupils or students’ results (*also see the following section, Teaching Analysis*). This, in turn, makes it possible for courses to be adjusted more quickly, helping the student and redistributing teaching resources to suit needs. A **performance monitoring** application, managed in the cloud, makes it possible to centralize and deal with data and information from multiple establishments, thereby allowing benchmarking that can re-energize teaching policies, as well as better inform pupils and their parents based on a series of criteria.

For example, the University of Wollongong in Dubai has introduced an ongoing and systematic assessment solution for its processes. Run by an “Office of Institutional Effectiveness”, the solution covers four areas:

- identification and definition of targets to be achieved, and definition of an appropriate strategy;
- implementation of specific programs enabling the targets that have been set to be achieved;
- identification of the results obtained and monitoring of progress achieved; and
- identification of the changes needed, and possible adjustment of objectives.

The **Software-as-a-Service** (SaaS) model applied to performance management or education lifecycle solutions enables the data about pupils or students to be saved and processed centrally, including information from several different establishments, with the data accessible to everyone everywhere. This is of great value for consulting outside office hours, for example, as well as for teachers who work in a number of schools, or if campuses are located far apart, or for teaching networks.

**Teaching analysis**

The continuous systematic gathering of data about the educational process for each student, and the use of that data after analysis using specific tools, can be valuable to teachers, pupils and students alike, as well as educational administrators.

For example, it allows for the:

- assessment of the performance of the education system or each individual establishment, enabling interested parties to track success rates, non-attendance, frequency of use of the resources made available, etc.;
- identification of good practices, initiatives and beneficial projects;
- assessment of students’s chances of success (with comparisons possible between establishments and even between networks);
- assessment of students as they progress, with the ability to use the gathered data to adjust study programs, teaching methods and the evaluation process in real time; and
- ability to anticipate the risks of students dropping out or failing at school.

Centralizing this information and these assessments enables the people involved (teachers, school management, and parents) to view the status and current results of every pupil or student at any time. They can also consult with each other and issue recommendations without having to meet face to face.
Innovative research

To be able to operate and be effective, researchers need to access information that is increasingly widespread and abundant, and scattered all over the world. Gaining access to the information and using it properly can be made possible by centralizing the resources. Solutions such as that used by the College of Pharmacy at the University of Rhode Island can now demonstrate their value (see Section IV – Good practices). If these portals are supplied and consulted collaboratively by research teams from various establishments, as well as by industry, they will have even greater value. The dynamic creation of communities and collaboration schemes between people who share common or complementary interests can have a stimulating effect on projects.

Research projects can also take advantage of shared calculation infrastructures – common pools of resources, accessible to everyone when they need them. This is a timeshare approach adapted to the concept of virtualization and the cloud.

Similarly, centralizing research data from a variety of sources may enable the results to be used more quickly – and hence speed up progress from the moment the data is processed by analysis and optimization software.
Conditions for the cloud to succeed in education

Whether supplied and managed by a commercial service-provider or a public operator (e.g., the region, community, or education network), a cloud environment has to offer a certain number of guarantees to users (e.g., regarding the ongoing integrity and availability of data; constant and effective accessibility to the data, applications or processing resources; confidentiality and security [hosted resources and transfers]; the ability to recover data and applications in the event of the contract being terminated, or in the event of bankruptcy or strategic modifications by the operator; and so on).

Implementing cloud solutions will require certain conditions to be fulfilled – in particular, optimum connections for all establishments (general high-speed network) and some changes to existing IT infrastructures and processes.

There will also be a need to ensure:

- the definition and implementation of simple and effective procedures for access – making data available and reserving space and resources;
- the qualification or certification of the quality of the content made available or disseminated (i.e., the need to guarantee reviews by experts and teachers through a “peer review” process);
- compliance with the privacy requirements on the confidentiality of data sent outside (e.g., for anything relating to assessment scores);
- the existence of an official body or department in each establishment to define strategy and who will monitor the use made of cloud services, as well as promote their use;
- definition of service criteria (SLA); and
- the control of certain new concepts for education establishments, such as the management of supplier relations.
Proposal to open up education to the cloud

The parties involved in education, whether schools, colleges or universities, have already adopted IT tools to varying degrees. The movement of teaching resources towards e-learning, DWS, content for IWBs, as well as the growing inclusion of collaboration tools and social networks in the education environment, are all demonstrations of the growing interest in acquiring and using new technologies.

Also, the speed of development and renewal of technologies, as well as the rising cost of large-scale deployment (despite some hardware becoming more affordable) and the lengthy process of public procurement contracts, all require thought about new models for rolling out IT and teaching tools and making them available.

While it is necessary for each establishment to provide an up-to-date technological environment that not only meets the needs of pupils and students, as well as the demands of our neo-digital society, it is unrealistic and counterproductive to expect or hope that every establishment should invest individually in equipment or developing applications and content. The same thing applies on a macroeconomic level from the point of view of the authorities and their ability to provide funding for equipment and content.

The cloud can contribute towards reducing the investments required and shortening the process for topping up available resources.

The potential benefits of the cloud are presented in this document. The various concepts, scenarios and themes presented are launchpads for projects that our local education providers can initiate. The principles of the cloud and the opportunity to pool resources will highlight the best projects, ideas or practices.

To implement these promises in French-language education, it may be of value to establish a series of pilot projects inspired in particular by some of the scenarios and themes presented here.

Issuing a call for projects would enable the universities and colleges, based on existing expertise or vision, to adopt a theme and make proposals. If that proposal is selected (based on criteria yet to be determined, such as technical and teaching progress and relevance, the potential for pooling and enhancing resources, the current existence of skills, etc.), the resulting solution could be offered as a service to other teaching establishments that would then become the clients or consumers.

Depending on the potential and prospects, the cloud solution could be rolled out, for example, to

- the infrastructure of the pilot establishment;
- the distributed infrastructure shared by several establishments; and
- the infrastructure of a cloud computing solution-provider.

For the needs of the development and test phases, and subject to reinforcing their existing infrastructure, the pilot establishments could use the standard private cloud platform already developed by EuroGreen IT (Mons).

The pilot projects selected as the result of a call for projects could also benefit from subsidies granted by the Belgian government.

The process of making each solution available to other interested education establishments would be in the form of Software-as-a-Service (SaaS). The method of payment would be a basic subscription, plus billing for usage. This would have the benefit of paying content authors for their development.
and minimizing the costs for users. The other major advantage of this approach would be that it would promote professional solutions that meet real local needs.

Each pilot establishment would be responsible for continuing the development of its solution, enhancing or improving it based on the proposals and requests of other interested parties.

To guarantee the relevance of the proposals and developments, a special steering committee could be established comprising representatives from colleges and universities, plus the public authorities as well as experts in the cloud and cloud computing. This committee would be there to make sure that the best terms for carrying out the projects can be guaranteed, including:

- appropriateness of the solutions provided;
- non-redundancy of developments and projects;
- advice and guidance on managing and optimizing infrastructure, content storage, platform security, fair billing of services, etc.;
- guidance in relations with any commercial service-providers;
- and
- guidance with cloud concepts (see Section VII).
Education for a Smarter Planet

Analytics, cloud computing and early-warning predictions can make our education systems smarter
The cloud from every angle
A cloud infrastructure can take one of four different forms:

- **Private cloud**: The cloud infrastructure is dedicated to a single user organization; it is implemented and managed by the organization itself (internal private cloud) or by a third party (external private cloud);
- **Public cloud**: An infrastructure offered by an external service-provider to any interested user - services are being used by a mass public client base;
- **Hybrid or shared cloud**: A model that incorporates and uses the resources of different types of cloud (public, private, etc.), which interact to suit needs (this assumes a certain level of technological harmonization between them); and
- **Community cloud**: A cloud infrastructure reserved for a community (i.e. for user organizations with common interests).

In terms of available services, the cloud model can serve a range of purposes, which can be combined, if required:

- **Infrastructure-as-a-Service**: The hardware and equipment resources (desktops, servers, storage systems, network equipment, etc.) are outsourced, totally or in part;
- **Platform-as-a-service**: This is an outsourced solution making available an application platform, an operating environment and tools for development, integration and monitoring, designed to authorize the management of applications in the cloud (which means that users can host their own applications there, too); and
- **Software-as-a-Service**: In this, the application or software is made available in the form of a service.

In addition to these three main models, there are other derivative or related models. In particular:

- **Desktop-as-a-Service**: This is a sub-scenario of Infrastructure-as-a-Service, where the desktops (workstations) are outsourced and hosted in the cloud through virtualization, while the hardware installed on-site merely takes on a display function;
- **Middleware-as-a-Service**: This is a concept similar to Platform-as-a-Service, although a little more restrictive, involving the outsourcing of middleware solutions, such as application servers, databases, messaging, BPM, etc.; and
- **Business-as-a-Service**: This is virtually synonymous with Business Process Outsourcing.
IBM Cloud Academy / Cloud Education Community

IBM has introduced a collaboration and sharing forum that enables schools from all stages of education – primary school to university – that have gone down the cloud route, to share and exchange good practices and ideas.

This allows schools to work together to enhance solutions already initiated, as well as to develop new applications and practices. The effect of putting together and sharing ideas between education establishments from multiple geographical and cultural horizons is to energize the concepts developed and implemented. The overall aim is to advance use of the cloud in the education sector, in terms of both the technologies and operating models that are used, and the skills that are developed. The forum enables education establishments to participate and uncover the principles and potential of the cloud in an environment specifically aimed at education.

The forum is open both to teachers and members of the teaching teams in education establishments, as well as to application and solution designers, IBM researchers and developers and technology partners.

As a result, the participating establishments are able to:
• familiarize themselves with new technologies and practices;
• use and supply resource databases (lessons, tools, practices, etc.);
• initiate pilot projects involving other establishments and partners;
• assess the technical, financial and organizational relevance of these projects; and
• publish or view reports, presentations, and reference documents.

The participating establishments undertake to:
• use cloud solutions and technologies, both for pilot projects or live projects;
• share their experiences, ideas and good practices with other participants to the forum; and
• pass on the results and lessons learnt.

More information at
www.ibm.com/solutions/education/cloudacademy