WHITE PAPER
Intel® World Ahead
Cloud Computing

The Education Cloud: Delivering Education as a Service

The education cloud can simplify, add value to and lower the cost of education transformations

FIVE KEY ELEMENTS TO EDUCATION TRANSFORMATIONS

The five interrelated elements shown in Figure 1 have consistently proven essential to support successful education transformation worldwide.

These five elements help to create sustainable improvements in education — improvements that give students the best possible opportunity to thrive in the global economy.

Figure 1. The five key components of education transformations

Robert Fogel
Principal Education Architect
Intel Corporation

Introduction

The massive proliferation of affordable computers, Internet broadband connectivity and rich education content has created a global phenomenon in which information and communication technology (ICT) is being used to transform education. Cloud computing is beginning to play a key role in this transformation.

This paper explains how an education cloud can provide affordable and high-value education services that support 21st-century skill development. Additionally, the paper outlines a general framework and specific actions that can help IT decision makers and government leaders identify and meet the needs of the education community, including students, teachers, parents and administrators.

By making ICT more affordable to implement and easier to integrate into classrooms worldwide, education can be transformed — and students across the globe can develop the critical skills they need to compete and prosper in the today's information society.

Education Transformation Is a Global Phenomenon

Education transformations can transcend economic and social barriers, providing equal advantages and opportunities to everyone who has access to ICT. In Portugal, for example, it took just two years for a nationwide effort to transform education and achieve significant economic benefits. Computers are now available to every primary school student in the country — moving Portugal to the forefront of digital education while also creating nearly 1,500 new jobs and adding EUR 2.26 billion to the country's economy.

The benefits of integrating ICT into education have been established by a variety of studies. Positive outcomes may include higher graduation rates, improved matriculation rates for higher education and improved national academic rankings. On a broader scale, over time the national benefits of bringing ICT into the classroom have included improvements in GDP, worker productivity and national competitiveness, as well as new jobs and the cultivation of entrepreneurship and innovation.[1]

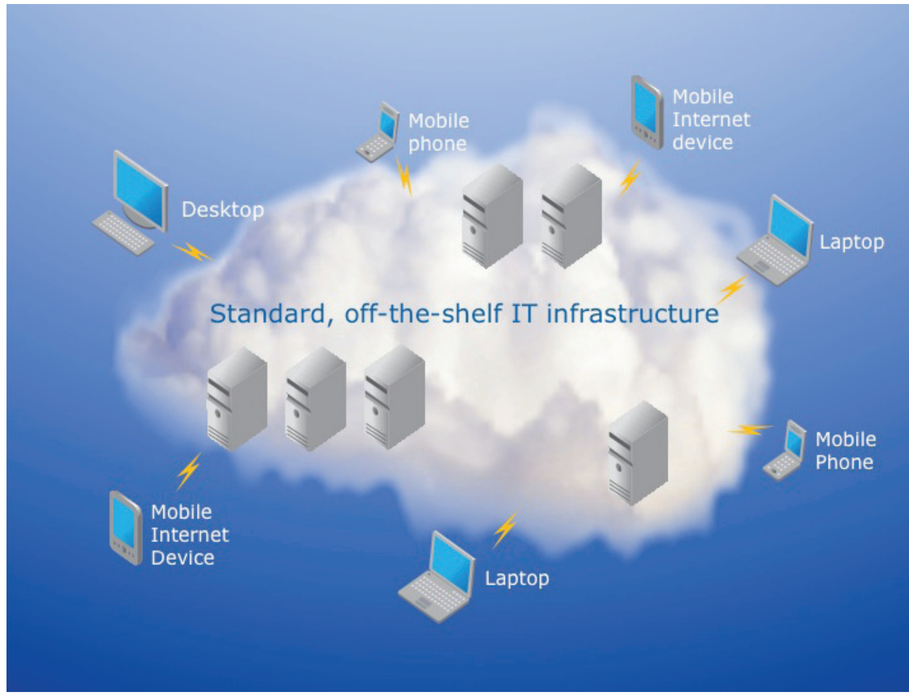

Figure 2. Cloud computing provides anytime/anywhere services that can be accessed from any device.

Cloud Computing Simplified

There has been much hype about cloud computing, and cloud computing has the potential to play a vital role in education transformations. But first, there remains a need to distill it into a practical, consistent, accessible framework for education.

To understand cloud computing in the context of education, it helps to begin by understanding the notion of "service." A service is a type of software function or capability that is accessible anytime and anywhere via a compute device such as a laptop, desktop, handheld PDA or cell phone. Some of the more common examples of cloud services are Google Apps, Amazon EC2 and SalesForce.com. Other, more generic services include wikis, blogs and e-mail.

From a user's perspective, a cloud can make all of these (and more) services available in such a way that the user does not have to be concerned with where the services originate or even where the services are running. The services are just "out there" somewhere, in the cloud, and the user can access them at any time, from any device (see Figure 2).

In reality, cloud services might originate in one place but actually run on a stand-alone laptop or cell phone, or on a server somewhere in cyberspace. It's also possible for a single service to be running on some combination of devices. Google Earth, for example, can run standalone on an individual laptop, but when the Earth image on the laptop has to be updated, those updates come from one or a combination of Google's data centers around the world.

The Education Cloud

To support education transformations, cloud computing can help government leaders and IT decision makers answer key strategic questions such as:

- What is the quickest, most efficient and affordable way to deliver education?
- How do I develop students' 21st-century skills and prepare students for the new job market?
- How do I encourage local innovation within a country or region?
- How do I share resources across districts, regions or the entire country?

With the flexibility and affordability of cloud computing, it is possible to answer these questions and develop education programs and strategies that also:

- Simplify, speed and reduce the cost of development, integration procurement, and operation and maintenance of ICT infrastructure
- Capitalize on worldwide innovation of developers
- Focus on the user experience and expected outcomes, not on infrastructure
- Simplify management of vendors
- Provide better visibility of results and impacts, using cause-and-effect analyses for continuous improvement

Example of an education cloud service: Student ePortfolios

The ePortfolio service is just one example of a cloud service that can be delivered to the members of an education community.

A student portfolio is a valuable record of a student's academic life. The record may include items such as assessments, evaluations, assignments, homework and classroom projects. These portfolios are critical for managing each student's academic progress, and — when student portfolios are collectively reviewed by the Ministry of Education (MoE) — they can also play an important role in managing the performance and progress of an entire education system.

Also called electronic portfolios or digital portfolios, ePortfolios present significant advantages over paper-based alternatives. One reason is their accessibility. End users — which may include students, teachers, parents, administrators and government officials (depending on the implementation) — can access ePortfolios at any time, from computers, cell phones or other devices. ePortfolios can be accessed by teachers to issue assignments, and by students to access assignments. A school principal can use students' ePortfolios to monitor the performance of the school, and parents can access their own child's portfolio in order to become more involved in their child's education.

Using cloud computing, the ePortfolio service can be designed in several ways. For instance, the service can run as a standalone service on a laptop, without connectivity. The service can also run from local school servers, from an MoE data center or from a third-party services provider that is accessed via the Internet.

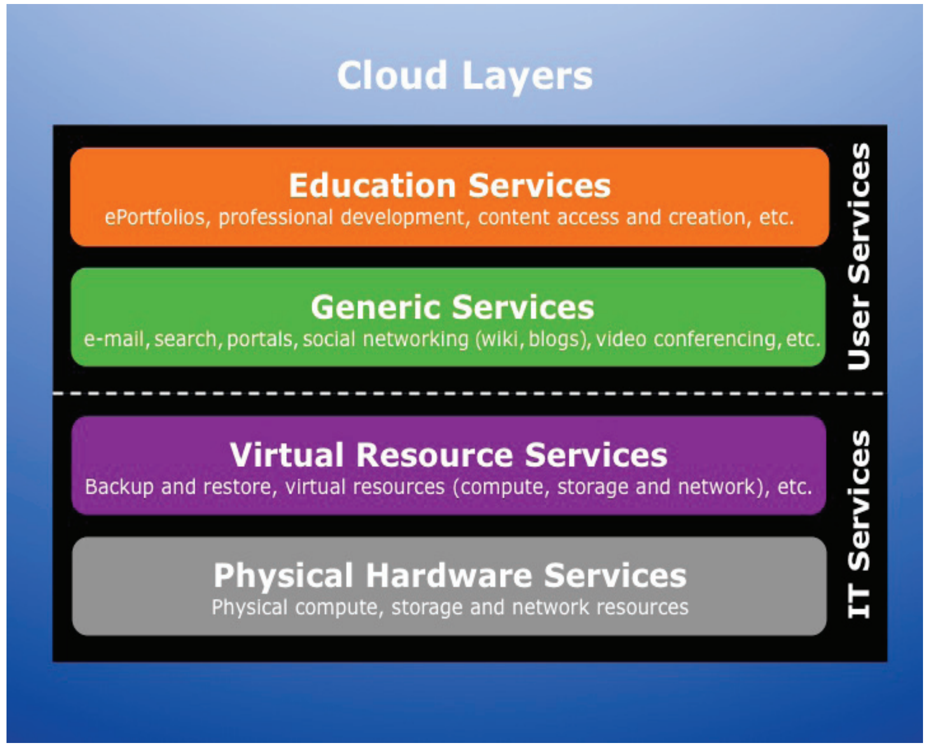

Figure 3. An education cloud includes both user services and IT services

Building an Education Cloud

One of the first steps in building a cloud solution is identifying the "layers" of the cloud, which include user services and IT services (see Figure 3). When you communicate with vendor service providers, these services and their associated parameters need to be defined in a request for proposal (RFP) or similar document.

User services

The "user services" shown in Figure 3 illustrate a few of the many education-specific and generic services the education community can access from devices such as laptops and PDAs.

It is important to create a "services catalog" that lists the user services that are needed in each education community. The services catalog — which may include a phased deployment plan, if some services need to be added over time — should be provided to vendors so that they know which user services they need to deliver.

A services catalog can include education-specific user services such as:

- An eAssessment service for managing student assessments
- Grade book, roster, lesson plan and classroom management services for teachers
- Content management services that teachers use to assign curriculum content to students and that students use to access the assigned content
- An online community service that teachers use to interact with peers and share lesson plans
- A professional development service that teachers use to manage their career development path and become more proficient on the use of technology in the classroom

The services catalog can also include additional user services that are accessible from the cloud but are not directly related to the delivery of education. These additional services might include:

- A fundraising service to track contribution and fundraising events
- A school asset tracking service to track equipment and supplies
- A school bulletin service to inform parents and the entire community of school activities

User services also include generic services, which often work with and support education services. As shown in Figure 3, these generic services include e-mail and social networks. For example, an ePortfolio service might employ an e-mail service as the primary interface between the ePortfolio and its users. A student could then receive assignments from the ePortfolio service via e-mail, and when the assignment is completed, the student could send the completed assignment back via e-mail.

Users can also access generic services directly, as when, for example, teachers and students use their e-mail accounts to interact with peers, colleagues, parents and others.

IT services

Once the user services have been identified, the next question concerns the type of underlying IT infrastructure that needs to be in place to deliver the education and generic services specified in the services catalog.

In Figure 3, the bottom two layers describe the IT services that define the infrastructure of the education cloud. These layers include:

- **Physical resources** such as client devices, school servers, the school network, MoE servers, national communication network, storage devices, etc.
- **Virtual resources** that simplify the management and access of the physical resources by aggregating the physical resources into a collective pool of resources. This aggregation and pooling is commonly referred to as virtualization.

EDUCATION SERVICES AVAILABLE ONLINE

Intel AppUp Center The Intel AppUp Center at www.appup.com/applications provides a resource center and catalogue for cloud-based mobile services. This site can also serve as a model for how an education services catalog could be created for the development and distribution of education cloud services. Another example of a catalog of education services is iTunes University at www.apple.com/education/itunes-u. This site is a large-scale distribution system for lectures, language lessons, films, labs, audio books, tours, etc.

Skoool.com An example of content services that can be integrated into an education cloud can be found at www.skoool.com. The site offers a number of learning objects freely available for use via the Internet, as well as a set of toolkits for open-ended learning.

Education elements An example of professional development services can be found at www.intel.com/education/elements, which features a set of online, self-paced courses that focus on helping teachers become proficient with project-based learning, student collaboration and 21st-century skills development. These courses can be integrated along with others and made available though an education cloud.

VIRTUALIZATION IN THE CLOUD

Virtualization is key to the cloud because it is through virtualization that services can run on many different devices and types of devices. From teachers' and students' perspectives, it does not matter where the services are running.

When physical resources are "virtualized," they can reside in a variety of physical locations. For instance, to facilitate a rapid deployment of services to a new school, the physical resources that are used to run those services might exist at another school, or be provided by a commercial services provider. Once that school's infrastructure is in place, then the services may be moved to run on that school's own servers. Doing so could result in reduced connectivity costs.

An example of a virtual resource service is backing up students' and teachers' client devices so that, if those devices ever stopped working, it would be possible to restore a student or teacher to another device. Other examples of virtual resource services include virus protection of clients and servers, and Internet filtering for inappropriate content.

Specifying cloud services

When communicating with vendors, it is necessary to specify the parameters for the cloud services you want and need. These parameters include the following:

- **Function** — This is the function or behavior of the service being specified — what it needs to do, or what capability it needs to have. For example, an ePortfolio service provides an electronic record of a student's academic life.
- **Interface** — This identifies the interface between the service being specified and any other services with which the service interacts. These interface(s) specify input/output behavior in order to characterize the interaction. For example, an ePortfolio service might interact with database services and an assessment service, and perhaps also with a content management service.

  Authentication, authorization and access (AAA) — This provides the primary security for the service being specified. For example, an ePortfolio service might permit access to the student for whom a particular ePortfolio exists, the student's teacher, the school's principal and the student's parents. For each of these people, the access rights and privileges might be different. For example, the teacher can assign a test for a student to take, but would not be allowed to actually take the test. The student may be able to access an assignment from the teacher, but would not be able to change the assignment.
- **User interface** — This specifies the interface between a potential user and the service being specified. The interface is often implemented in terms of options and actions that can be selected or performed by a user. Note that there might be multiple user interfaces for a given service. For example, an ePortfolio service might have a user interface for a teacher to make assignments, another user interface for a student who can use his or her portfolio to access assignments, another for a school principal to monitor the performance of the school, and still another for parents to access their own child's portfolio.

  For each interface, the behavior may be different and the AAA may be different. When a teacher accesses the ePortfolio service, that teacher may be presented only with specific options and actions, such as issuing assignments or collecting a grade from a test. A student would be presented with an entirely different set of options and actions, such as accessing content assigned by a teacher or taking a test.
- **Performance** — This is an essential specification that defines the expected delay or time frame for the service to perform its function. In an ePortfolio service, for example, the MoE might expect to be able to view a summary of all students' grades within a 48-hour period.

- **Cost** — This is the cost of the service being specified. In some instances in which a service is free and in the public domain, there may not be any cost associated with that service; however, commercially provided services always have a cost model associated with them. The range of possible cost models includes:
  - **Pay-for-use model:** A cost is associated with use of the service, either for each instance that the service is accessed or for the period of time that the service is accessed.
  - **Membership or subscription model:** Typically applies a generic charge for a period of time such as a month or year, after which memberships or subscriptions have to be renewed.
  - **One-time license model:** A license is purchased for a one-time fee.
- **Footprint** — The footprint describes how the specified service gets delivered to an end user. For instance, a service could be streamed across the Internet, pre-installed on client devices, or packaged and sent to client devices. In hybrid footprints, such as Google Earth, part of the service resides on a client device and part of it is streamed.
- **Client device awareness** — This is the ability of a service to be aware of the type of device on which it is running or by which it is being accessed. Depending on the device, the service may behave differently or have different capabilities. For example, the same service may be accessed via a laptop or from a cell phone. The cell phone might be used to inform a student that a project is due the following day, and the student would use his or her laptop to complete the project.
- **Support** — This is the required support expected for the service, and is typically specified in terms of a Service-level Agreement (SLA).
- **Physical location or environment** — This is the physical location in which the service being specified actually runs. For example, a country may not want any of its student ePortfolios to be stored outside the country. Or, part of a student's ePortfolio may exist on the local school servers and part may exist on the MoE's data center servers.
- **Level of connectivity** — This is one of the most important parameters for specification of a service. It defines the level of network or Internet connectivity that is available for the service being specified. There might be absolutely no connectivity (offline), occasional connectivity (offline/online), or always-on connectivity (online). A common misconception is to equate cloud with the Internet (always online or always connected), but in fact cloud computing can be employed in offline or offline/online environments.

  The most common level of connectivity specified is an occasionally connected offline/online model. This model is often best, even for environments in which the network/Internet quality is extremely high, because it allows for mobile usage. Mobile client devices are sometimes taken to places (airplanes, remote areas, etc.) that lack a network connection.

  Cloud-based education services should support mobile connectivity so that teachers can always be teaching and students can access learning materials at any time, from any device. Ideally, services should be able to run at different levels of connectivity, such as across the Internet or a national intranet, as well as from MoE data center servers, third-party service providers, local school servers, or standalone teacher and student laptops.

ADDITIONAL CLOUD EXAMPLES AND RESOURCES

Clarkstown Central School District The Clarkstown Central School District uses Google Apps to coordinate curricula and resources within schools and across the district. Innovative uses of the calendar, shared documents and shared sites make it easy for teachers to follow district curriculum plans, keep up with school-related events, and create and share curriculum resources.[2]

Laboratory for Continuous Mathematical Education, St. Petersburg, Russia This project, supported by an HP Innovations in Education grant, connects students with scientific researchers, giving them an opportunity to experience professional research practices while also building their own technical skills. The students work with researchers from both scientific and industrial professions.[3]

Columbia Secondary School A partnership between the New York City Department of Education, Columbia University, and the Columbia Secondary School has led to the deployment of cloud-based systems including a custom content management system and Google Apps. The students are using these cloud applications to do research and to collaborate in new ways.[4]

Eagle County School District The Eagle County School District in Colorado is implementing a cloud computing system that will make tools for e-mail, word processing, presentations and calendaring accessible to everyone in the district.[5]

Cloud-Computing Infrastructure and Technology for Education (CITE) This project, from MIT's Climate Modeling Initiative, looks at ways to use cloud computing resources to perform scientific research, both in university labs and in K-12 classrooms.[6]

TeacherTube This cloud-based video service is modeled after YouTube but is designed specifically for teachers, schools and homeschoolers. It offers a wide range of educational videos on a variety of topics.[7]

Examples of Education Clouds

The real power of education clouds becomes evident when viewed from a user's perspective. As depicted in Figure 4, a set of users (including students, teachers, parents and others) can access a variety of education cloud services, using whatever device or devices they have access to (laptops, desktops, PDAs, etc.). A common cloud infrastructure like the one illustrated in Figure 4 can scale services across dozens or even thousands of schools.

If an ICT infrastructure is already in place, an education cloud facilitates the integration of this existing infrastructure with new technology and solutions. The cloud also "wraps around" the existing infrastructure so that it can be accessed as services. In instances in which there is little or no existing infrastructure, an education cloud helps to make cloud-based services available more quickly to schools, as well as to teachers and students.

Services integration

When building a national-scale education cloud or any large-scale IT infrastructure, it is a common practice to employ a system integrator (SI) to integrate all of the pieces of a system. However, SIs can be very expensive and can consume valuable time in defining requirements and designing a custom system that often locks in the use of the SI's own products and consulting services.

Cloud computing offers different business dynamics and a new way for systems to be built. This creates a world of new opportunities for services integrators, who are motivated to continually innovate and deliver more and better value-added services instead of relying on consulting services. The cloud computing model is depicted in Figure 5, which shows a telecommunications company, or telco, serving as a services integrator for higher-education research.

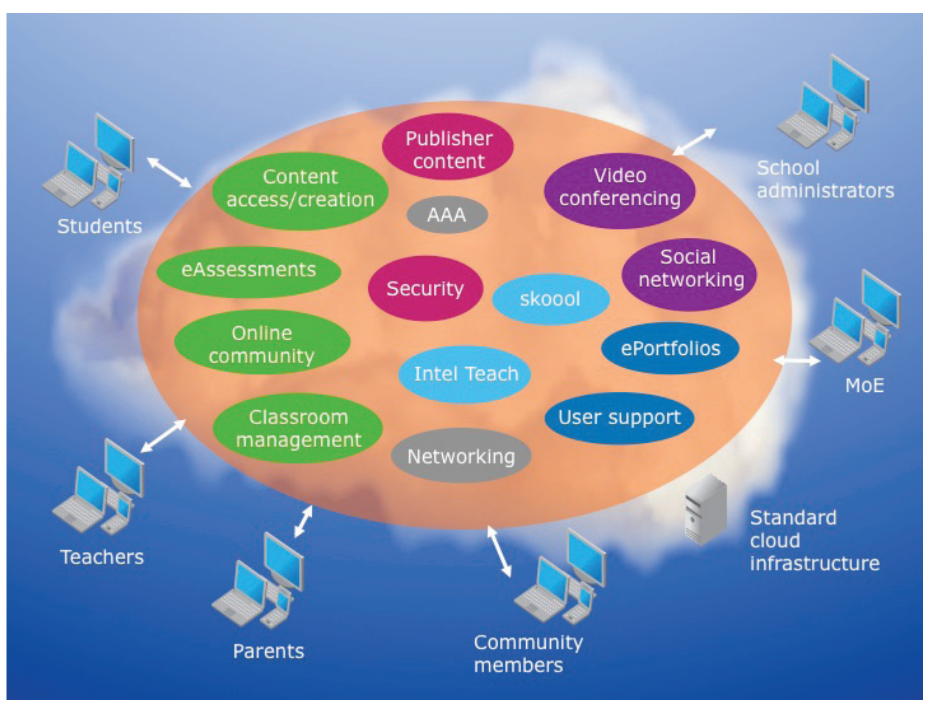

Figure 4. K-12 education cloud example — user's perspective

Note that research collaboration is one of the most important functions for universities and is often a challenge because of the need to share intellectual property (IP), as well as the prevalence of resource silos and the difficulty of creating user-friendly collaborative environments.

In the example shown in Figure 5, three universities are engaging in oil and gas research, and each university has its own IP (in the form of services) that it is making available for the collective research. The telco integrates the IP from the three universities, along with the telco's own value-added services and other cloud services that are publicly available.

The result of the services integration illustrated in Figure 5 is a virtual collaboration environment (VCE). When viewed from a user's perspective in Figure 6, this VCE is shown to be a powerful tool that allows researchers to access — at any time, and using any device —a wide range of collected, cloud-based services. The researchers can focus on their research without concern for where the services originate or where and how they are running.

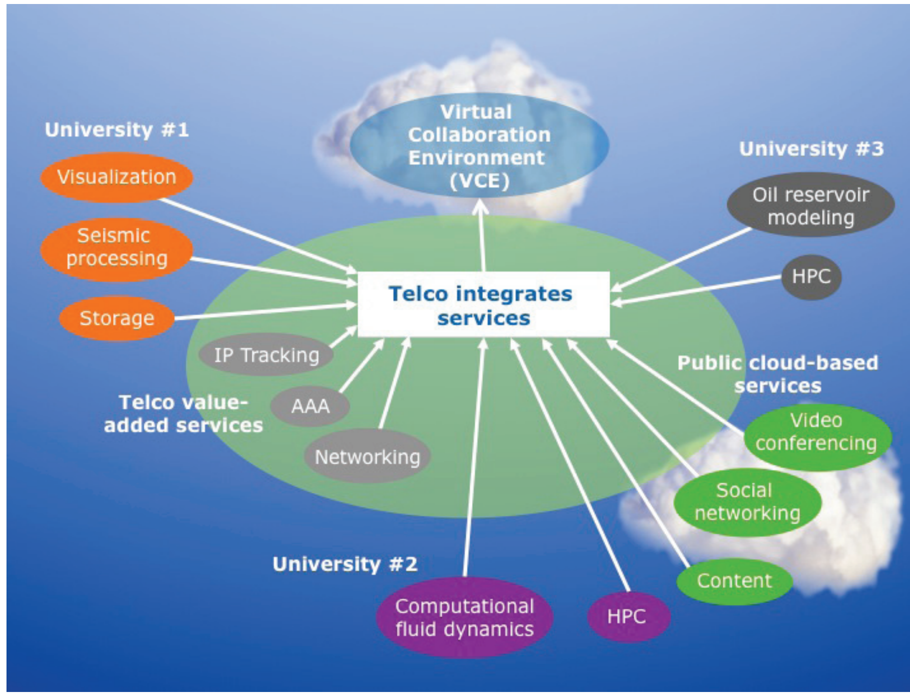

Figure 5. Higher-education cloud example — provider's perspective

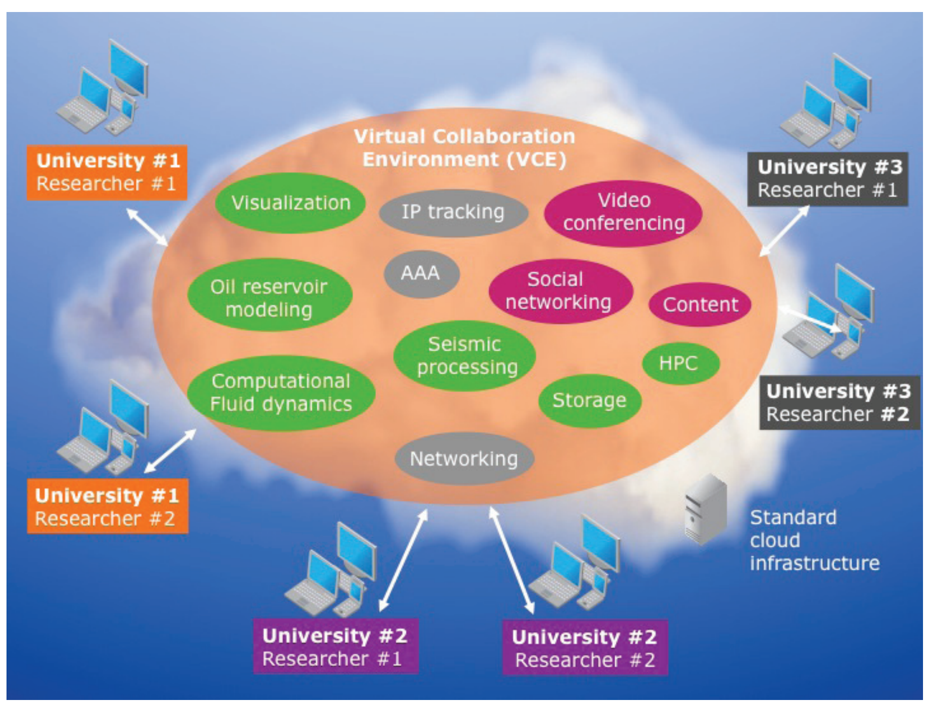

Figure 6. Higher education cloud example — user's perspective

Conclusion

Cloud computing can help communities — and nations — transform education. An entire world of knowledge can now be made available to teachers and students through cloud-based services that can be accessed anytime, anywhere, from any device.

By helping countries worldwide lower the cost and simplify the delivery of educational services, cloud computing enables students across the globe to acquire the 21st-century skills and training they need to compete and succeed in the global information society.

Achieve Your Vision

You can play a key role in the education transformation in your country by implementing a sustainable, affordable education cloud. For information, guidance and support, visit **Intel.com/ITCenter.**

[1] See, for instance, "The Economic Benefits of Strategic ICT Spending." http://govtech.firstlightera.com/EN/Microsites/1/Intel/WhitePapers

[2] http://docs.google.com/fileview?id=0B5AOHQcS-cAeZDA1N2QzZjctOGYzYS00YjZiLThkMWUtNTUxMTRhYTcwN2Mw&hl=en

[3] http://www.lcmespb.ru/

[4] http://www.google.com/a/help/intl/en/edu/case_studies/columbia.html

[5] http://www.edtechmag.com/k12/events/updates/infrastructure-the-highway-to-21st-century-learning.html

[6] http://www-paoc.mit.edu/cmi/technologies/cloudcomputing.htm

[7] http://www.teachertube.com

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