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Rising Above the Clouds: A Review of the Implications that Cloud Computing Technologies Hold for Education

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Abstract

This paper explores the impact of cloud computing on education at both the macro/institutional level and the micro level of student learning. It argues that the technology not only benefits educational institutions through simultaneous cost reductions and enhanced functionality, but that it can also develop students' capacity for self-regulated learning and lead to an increased engagement with the subject material.

Keywords: Cloud Computing, Education, Personal Learning Environment (PLE), Self-Regulated Learning

Introduction

As technology develops, it transforms the manner in which we engage with each other and society. Thus, it becomes increasingly incumbent upon us to question how the nature and purpose of education should address such transformations. Cloud computing occupies the apex of a developing technological shift in how we construct, access, manipulate and communicate with information through services. As such, it is often argued that the technology has the potential to positively change education not only at the institutional level (schools, universities, etc.) but also at the fundamental level of the students' relationship with their own learning.

This paper first discusses the potential financial benefits that cloud computing technologies can offer to educational institutions. This is primarily with regard to enhancing functionality whilst simultaneously reducing the burden of hosting expensive and resource intensive IT infrastructures. It then describes the manner in which the adoption of cloud computing technologies can facilitate and enhance student engagement, especially for 'experienced' users. Such a student centred focus subsequently provides a context to explore how cloud computing can transform the nature of student learning. This is achieved by enabling pedagogies that widen the scope for collaboration, self-directed learning and meta-cognitive development.

Cloud Computing

Perhaps fittingly for its name, the term 'Cloud Computing' evades any orthodox definition and is instead characterised by a nebulous cloud of varying descriptions. A study by the global management consultancy firm McKinsey highlighted no fewer than 22 possible separate definitions of cloud computing (McKinsey & Co, 2009). From a minimalistic viewpoint, however, it can be argued that there are at least three key elements required for a technology to be described as 'cloud computing'. These are: (1) A cluster of distributed computers (often realised as server farms or a collection of data centres). (2) The capability of providing on-demand access to computing resources and services. (3) A network medium, predominantly the Internet, via which such services are provided (Sultan, 2010). In addition,

Cloud computing is commonly organised into three distinct models of service delivery: namely, Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS). Collectively, these three models provide remote and on-demand access to the full gamut of traditional locally based computing services, at the infrastructure, platform and software level.

For the purposes of this paper, cloud computing is best conceptualised as a higher level abstraction of a collection of constituent technologies, including application service providers, grid and distributed computing, Web 2.0 environments and online storage services. Although not fundamentally novel, it represents a paradigm shift in the way that information technology (IT) is conceptualised by 'commoditicising' it in a

manner that was not possible before (Sultan, 2010). Limited parallels can be drawn with the on-demand provision of water and electricity. Although taken for granted now, they were analogous paradigm shifts to cloud computing in their own time. However, unlike such public utilities, cloud computing is a rapidly evolving, highly personalised technology, which will most likely require new conceptualisations in subsequent years.

Benefits of Cloud Computing for Educational Institutions

The on-demand provision of computing services via a cloud provider confers several benefits to educational institutions of all strata. Economical benefits, simplicity and convenience of delivery and access to cloud-based services have been the predominant motivators behind institutions' adoption of cloud

computing services (Erdogmus, 2009). By adopting cloud services and freeing themselves from the expense of installing and maintaining hardwares and applications locally, institutions can significantly reduce the burden on their IT budgets (Leavitt, 2009). The hosting of IT services in the cloud shifts much of this expense to a pay-as-you-go model, which can offer significant cost advantages (Lin et al, 2009). Furthermore, the local hosting of an IT infrastructure incurs significant costs due to the electricity consumption of the hardware and the cooling facilities that it necessitates (Sultan, 2010). Indeed, external directives such as the Carbon Reduction commitment and EU Energy Using Products Directive are likely to exert considerable strain on educational institutions to improve the green credentials of their ICT infrastructures (James & Hopkinsons, 2009). Thus, the reduced energy consumption achieved from migrating an

institutions' IT resources to the cloud, may also offer an appealing solution for such institutions to meet their carbon reduction requirements (Katz, 2008). However, there is considerable debate concerning the green credentials of cloud-computing technology at the global level. Many have argued that although individual institutions are able to reduce their energy usage, in actuality, such reductions are simply coalesced at colossal and incredibly energy intensive data-centres and server farms (Koomey, 2007).

Another manner in which Cloud computing can provide significant savings is by reducing the labour-related costs of hiring technical staff to maintain a locally hosted IT infrastructure. Additionally, the high rate of change and development that is endemic to IT, places a significant financial

burden on education institutions. In order to remain competitive, these institutions are often required to routinely upgrade or renew their software and hardware systems. The migration of IT infrastructure and services to the cloud enables educational institutions to reduce such renewal expenses and the allied costs of re-training or hiring new support staff.

Survey of Examples

The implementation of cloud based services has been realised in educational institutions at the SaaS, PaaS and IaaS levels. Students and staff at schools, colleges and universities have benefited from the cloud based provision of; software such as email accounts, operating systems, productivity applications, malware detectors and cleaners; hardware such as processing

power and servers; and platforms such as operating systems and coding environments.

For example, faced with a limited IT budget and resources Kentucky's Pike County district signed a five-year agreement with IBM in 2008. The agreement provided the county with IBM virtual desktops or 'Desktop as a Service' (DaaS) which enabled on-demand access to storage, system servers, and VMware virtualisation technology. In such a cloud environment, processing takes place at the server level and not locally on individual machines. This enabled the schools of Pike County to save 1400 outdated computers from the scrapheap by transforming them into fully functioning thin clients or dumb terminals. By migrating a large part of their IT infrastructure to IBM's cloud system, it was estimated that the costs incurred over

5 years would be less than half the expense of supporting such services locally (Lambert, 2009).

The adoption of cloud services has also recently been taken up by several UK universities. Leeds Metropolitan University, the University of Glamorgan, the University of Aberdeen, the University of Westminster, the London University's School of Oriental and African Studies (SOAS) and the Royal College of Art (RCA) have all adopted Google Apps, providing email, word processing, spreadsheet, and shared calendars to their students. Interestingly, the reason behind this move was not only due to the financial benefits afforded by cloud computing, but also as a result of popular demand from the students themselves. In these cases, students were abandoning the Universities' internal email systems, due to its lack of functionality, reliability and students'

preference for their personal cloud-based email services (Hicks, 2009). This often led to important university emails being redirected to the spam folders of students' personal email accounts.

Furthermore, at the University of Westminster, storage issues with internal network servers and emails meant that students were more often than not, saving their work to USB memory sticks which were often prone to loss or misuse. The new Google system provided each student with up to 7.3GB of email storage capacity. This resulted in students no longer requiring the use of their USB memory sticks (Sultan, 2010), and also enabled them to access their work from any location (providing they possessed internet access). Additionally, Google Apps also allowed students to use their mobile devices to access their emails and save

documents remotely. This can facilitate increased engagement with their studies, as students have constant access to their university lives through their personal devices. It is interesting to note that much of the motivation behind colleges' and universities' shift to cloud based services is in order to keep up with the digital practices of their students, whom are often forerunners in the adoption of new digital technologies (Levin, D et al., 2002). Failure of educational institutions to adapt to the practices of their students can ultimately lead to the students disengaging from the institution as they have access to more appealing IT services elsewhere. This may result in a diminished relationship with the institution and as a result may subsequently exert a deleterious effect on their learning.

Educational institutions are also benefiting from cloud computing services in terms of increasing their capacity to conduct computationally advanced and intensive research. Such services provide researchers and postgraduate students with the required specialist software and hardware capabilities to run computationally intensive analyses, simulations and experiments. For example, by renting processing time on Google's powerful cloud-based servers, researchers at the Medical College of Wisconsin Biotechnology and Bioengineering Centre are able to conduct the normally extremely expensive process of protein research (Sultan, 2010). Furthermore, the increased accessibility of intensive computing resources may lead to a democratisation of scientific research. This is by enabling researchers with limited funds or institutional support to set up and customise their own systems to run data analysis

(La Susa, 2009). As more and more scientific research becomes dependent on the analysis of very large collections of data, a case can be made that cloud computing may help to facilitate the development of a truly collaborative and inclusive scientific research community.

In addition to the contributions that cloud computing can provide at the highest level of education and research, the technology also offers benefits for education in developing nations, which lack even the most basic of IT infrastructures (Wanjiku, 2009). For example, a number of African educational institutions have adopted cloud computing in order to address their inadequate IT infrastructures, meagre budgets and paucity of skilled technicians (Sultan, 2010). Google has established partnerships with a number of East African educational establishments (such

as the National University of Rwanda, the Kigali Institute for Education, the Kigali Institute for Science and Technology, the University of Nairobi, the United States International University, the Kenyan Methodist University and the University of Mauritius). These institutions are benefiting from Google cloud services including, Gmail, Google Calendar, Google Talk, Google Docs and Spreadsheets (Wanjiku, 2009). School teachers in Ethiopia are also benefiting from cloud computing technology, where Microsoft has administered 250,000 laptops running on its Azure cloud platform. This is enabling teachers to download curricula, monitor academic records and to securely transfer student data throughout the educational system, without incurring the expense of facilitating such services locally (Chan, 2009).

Issues for the Adoption of Cloud Computing

Although cloud computing holds the potential to deliver promising new horizons to education, both at the highest and most nascent levels, it is important not to fall victim to a myopic view of the possible problems and drawbacks that accompany the technology. Concerns have been expressed with regard to control and ownership of data, vendor lock, unreliable performance, security, privacy and latency to name but a few (Sultan, 2010; Leavitt, 2009). One hurdle which has prevented educational institutions from adopting cloud computing are the legal issues resulting from anachronistic governmental policies. For instance, the prohibition against transmitting some types of personal data outside of the EU, and the UK's Data Protection Act (DPA) of 1998 which obligates institutions (not the cloud-

provider) to be responsible for the protection of its users data. Furthermore, the distributed and external nature of cloud services is often in conflict with the internal policies of educational institutions. For example, the University of Westminster was restricted in its full adoption of Google Apps, as its policies dictate that all calendar, teaching, research, legal and employment information be maintained on University-owned systems (Sultan, 2010).

Although such issues of security, privacy, legality and reliability are as of yet unresolved, they also provide the impetus for the continual development and maturation of the technology. For example, Amazon's launch of its virtual private cloud (VPC) service, which aims to address issues of security and control, and the establishment of the Cloud Security Alliance, which aims to

encourage the widespread adoption of 'best practices' for the provision of secure cloud computing services (Cloud Security Alliance, 2013). Additionally, in some cases, the adoption of cloud computing systems can result in a greater than expected expense for the institution. In a study by KPMG, one-third of the 650 businesses surveyed remarked that the cost of moving to cloud-based platforms was higher than expected. Typically, in the hype surrounding the cloud, such businesses were unaware of the time and costs involved in re-structuring existing business and IT architectures to accommodate cloud-based resources (KPMG, 2013).

The fact that institutions occupying all levels of the educational hierarchy are embracing cloud computing is a testament to the wide variety of benefits that the technology can offer. From the

reduction of costs, complexity and inconvenience; to the improvements in functionality, student engagement and green credentials, cloud computing holds the potential to fundamentally transform the relationship between IT and the education sector. Moreover, the technology also holds the potential to transform the relationship between learners and their subject of study itself. By enabling, collaborative and personalised learning environments, cloud computing can increase students' engagement with their studies, in addition to enhancing their academic confidence, self-regulated learning skills and meta-cognitive abilities. These ideas will be explored in the following section.

Transforming Learning

As technology develops, it transforms the very nature of society (Castells, 1996). Therefore, if a predominant role of education is to prepare citizens to participate in society, the advent of a new major technology raises important questions concerning the form and function of education in that society (Egan, 1997). However, vestigial artefacts from the era of industrialism still largely inhabit contemporary educational systems. This can be witnessed in the predominance of the individualised assessment of technical and propositional facts and a deference to established authorities of knowledge (Robinson, 2010). Yet, today's post-industrial society increasingly requires graduating students to negotiate dynamic digital environments, whilst displaying competency in innovation, leadership,

multidisciplinary collaboration, and collective problem identification with colleagues of diverse ability and knowledge (Partnership for 21st Century Skills, 2008).

Thus, two questions are in order; firstly, can cloud computing technology be utilised effectively as an educational tool to enable students to learn essential 21st century skills? Secondly, what are the most effective ways to utilise cloud computing technology to fulfil this aim? These questions are further discussed in the following sections.

Affordances of Cloud Computing Technologies

Educational researchers are increasingly highlighting the unique affordances that cloud computing technology can provide to

more effectively develop the skills required of students by contemporary society. Furthermore, Hilton (2009) argues that the capacity of cloud based technologies to empower students to take charge of their own learning, is calling into question the traditional, unilateral relationship between the learner and teacher. In the context of cloud based technologies, students naturally engage in learning that is highly self-directed, autonomous, community based and linked to their everyday informal practices (McGloughlin & Lee, 2010). Thus, it is an educational fallacy to consider learners as passive information receivers rather than active analysers and co-producers of content. However, many educational institutions still view the educational value of IT as a tool to simply facilitate information retrieval and to augment traditional teaching approaches (Dede, 2008). Such passive IT technologies (e.g. course and learning

management systems) fail to capitalise on the pedagogical affordances of collaborative cloud-based technologies (McGloughlin & Lee, 2010). Recent research efforts have focused on identifying exactly what these affordances are, and in particular, how they facilitate the development of 21st century skills.

The fact that the services provided by cloud computing are largely non-proprietary, decentralised and accessible from a range of locations and devices, enables the creation of online environments that can facilitate learning and engagement. These environments are characterised by features such as openness, personalisation, collaboration, social networking, social presence and user-generated content, (Dabbagh & Reo, 2011b). In such an environment, users themselves are as important as the content

that they upload and share (Cormode & Krishnamurthy, 2008). Conceptually, in this environment, 'knowledge' is authenticated not by a call to a centralised authority or source, but through the peer review process of an engaged participatory community (Dede, 2008). Therefore, instead of the passive absorption of information, cloud computing environments are more able to engender practices which are self regulated, participatory, collaborative and distributed.

The user centred, participatory culture engendered by cloud computing, and in particular its web 2.0 manifestations, parallels and thus also facilitates the pedagogical philosophy of constructivism. In contrast to conceptualising students as a tabula-rasa or blank slate, constructivism emphasises the importance of learners taking charge of their own educational

development. In the constructivist approach the teacher acts not as an authority of knowledge, but as more of a coach who guides students through their own learning experiences (Driver, 1994). Thus students are not delivered pre-prepared authenticated knowledge, but are expected (with sufficient scaffolding from their teacher) to seek, analyse, make sense of and produce knowledge themselves and in collaboration with peers (Driver, 1994). The constructivist consonant learning environments engendered by cloud-computing technology can be contrasted with the traditional IT and 'web 1.0' environments which still inform much of today's use of IT in education. Such pre-cloud web 1.0 technologies are reflective of the 'classical' pedagogical approach of didacticism, where 'authenticated' knowledge is organised and delivered passively to learners by knowledgeable experts (Dede, 2008).

However, such an approach to IT in education is not amenable to today's cloud-computing environments. The capacity of cloud computing to host and deliver content and services in external and publicly accessible spaces, enables learners to source, organise and share knowledge themselves and in collaboration with peers. Specifically, cloud computing technology provides four main features which enable more self-regulated, collaborative learning:

1. User-defined linkages between users and content (e.g., posting on others' pages).
2. Simple mechanisms to share content and multimedia (e.g., blogs, wikis).
3. Prominent personal profiling (e.g., displaying user

preferences on customised profile pages).

4. Inter-technology applications (e.g. embedding media, videos and apps into blogs).

(Greenhow, Belbas and Hughes, 2009).

Many argue that the integration of such cloud based and web 2.0 technologies into educational approaches, enables the creation of personal and social learning spaces. Such learning spaces offer the potential to develop learners' sense of belonging to an academic community, self-regulation skills, meta-cognitive faculties and academic identities (Dabbagh & Reo, 2011b; McGloughlin & Lee, 2010). These affordances will be discussed in the succeeding sections.

Community and Connectedness

It has been argued that cloud computing and its constituent web 2.0 technologies are inducing a pedagogical transformation where the community, rather than being a path to accessing the curriculum, is the curriculum (Katz, 2008). This community oriented approach to learning is consonant with sociocultural theories of education, which posit that for learning to be effective it must be embedded in participatory and meaningful social practices (Engeström, 1987). Jenkins argues that the interconnectedness, creative capabilities, and interactivity offered by cloud based technology, permits learners initiation into a digitally located 'participatory culture' (Jenkins, 2006). The creation, sharing and valuing of one's digital productions with other members of the learning community, may then result in an

increased sense of social connectedness and a belief that the contributions that one makes to the community actually matter (Jenkins, 2006).

These assertions have been supported empirically in a number of studies. For example, Harrison (2011) found that university students' participation in a blog about their studies, helped to increase engagement and reinforce classroom learning by enabling communication about the learning to continue with peers outside of class hours. Correspondingly, Churchill (2009) discovered that students' utilisation of blog-based environments helped to foster a learning community where the learners felt they were important and that their contributions and opinions mattered. Furthermore, Hemmi, Bayne, and Landt (2009) investigated the use of cloud based, web 2.0 technologies in three

courses spread across two semesters. One undergraduate course used a visually rich wiki to augment teaching and learning, whilst another used blogs to facilitate participation in classroom discussions. The third course examined how a range of social media technologies such as Facebook, Second Life, Delicious, blogs and wikis supported learning. The study revealed that the adoption of all such technologies engendered a pedagogical shift towards more group oriented and collaborative modes of inquiry. This in turn facilitated the development of team work and group regulation skills. Finally, communication scholars Ellison, Steinfield, and Lampe (2007) investigated university students' informal use of Facebook and discovered that intense Facebook use correlated with an increased sense of social belonging to the university. This is of note as it is well established that learners, who feel a sense of social connection to their learning

communities, demonstrate stronger academic performance (Zhao & Kuh, 2004).

Overall, the research suggests that cloud computing and web 2.0 technologies can engender collaborative learning communities which may result in students developing an increased engagement and sense of connection with their studies. However, by requiring learners to seek, organise and synthesise content themselves, the use of such technologies can also facilitate the development of self-regulated learning skills and meta-cognitive faculties (Dabbagh & Reo, 2011a).

Towards Self-Regulated Learning

Self-regulated learning is defined as a student's ability to independently and pro-actively engage in self-motivating and behavioural processes that increase goal attainment (Zimmerman, 2000). Specifically, the use of cloud computing and web 2.0 technologies to increase self-regulated learning has been conceptualised by some researchers as taking place in a Personal Learning Environment or PLE (Dabbagh and Kitsantas, 2012). Simply stated, a PLE describes a learners own cloud based portfolio of learning history, resources, networks and content, and can be distributed across a range of services such as blogs, wikis, social networking profile pages, comment sections and online storage and bookmarking sites. PLEs are built on externally hosted (in-the-cloud) web 2.0 tools and services,

which facilitate students in aggregating and sharing resources. This enables them to participate in collective knowledge generation whilst also managing their own meaning making (Dabbagh & Reo, 2011b).

PLEs were highlighted in the 2011 Horizon Report as a key emerging technology which is likely to have global pedagogical implications for teaching and learning in the near future (Johnson, Adams, & Haywood, 2011). The ongoing EDUCAUSE Learning Initiative (ELI) (2009) “seven things you should know about” series define PLEs as the 'tools, communities, and services that constitute the individual educational platforms that learners use to direct their own learning and pursue educational goals'. McGloughlin and Lee (2010) posit that PLEs empower students to take charge of their own learning by prompting them to select

tools and resources to create, organise and package learning content to learn effectively and efficiently. PLEs are inherently self-directed as they place the responsibility for organising learning not on the teacher but with the individual learner themselves. Furthermore, PLEs require the development and application of self regulated learning skills because they are built bottom-up, starting with the learner's personal goals, information management, and individual knowledge construction (Dabbagh & Reo, 2011a).

The use and construction of such PLEs can also engender meta-cognitive development through the process of peer assessment. The uploading and hosting of learners work to public online spaces, enables them to engage in peer assessment through commenting, evaluating and augmenting each other's

contributions. Black (2002) demonstrated that by critiquing the work of others, students are forced to think about important questions such as what makes a good piece of work, how the work can be improved, and what are the main aims and points of the work. Black found that by developing such faculties in students via peer assessment, the students were more able to direct and reflect on their own learning, thus increasing the quality of their work. Traditionally, such meta-cognitive abilities to judge the efficacy of academic work are not developed in students, but instead are often the sole jurisdiction of the teacher. In controlled experiments, it was found that peer assessment improved student attainment by an average effect size of 0.3 standard deviations. Though seemingly small, Black notes that such improvements, produced across a school, would raise a

school in the lower quartile of the national performance tables, to well above average (Black, 2002).

Identity Issues

The public and collaborative capabilities afforded by PLEs and cloud based technologies, can also facilitate building more positive (and negative) academic identities for students. Symbolic interactionist perspectives argue that our construction of our identities is determined by our interaction with our environment and peers (Blumer, 1969). Traditionally, the inequitable power relations in the classroom between the knowledgeable teacher and ignorant student, often results in many students constructing poor academic identities, where they

perceive themselves as dependent on a ‘superior other’ for learning.

However, in a cloud computing based environment, where learners can engage as members of a participatory web culture which allows them to contribute, consume and comment on content, they are more able to construct online identities as self motivated members of an academic community. In addition, the capacity for personalisation and merging of informal learning available in PLEs and cloud based technologies in general, can enable students to connect their personalities and indigenous identities to their academic lives. This may enable them to build projective academic identities which are not in conflict with their identities outside of the formal learning environment, see (Barton et al., 2008). However, such technologies present a

double edged sword, as they also open the door to potentially unproductive interactions, harmful public scrutiny, and threats to privacy that undermine students' construction of positive academic identities and consequently their learning.

Navigating the Cloud - a Three-Phase Model

Although cloud computing technologies can enhance learning, in order to successfully leverage the benefits of such technology, learners must be able to acquire the necessary skills to do so. Cigognini et al. define such skills as personal knowledge management (PKM) skills, and describe them as the act of managing one's personal knowledge through technologies. PKM skills, range from creating, organising and sharing digital content and information, to higher order and more complex skills such as

the ability to collaborate and connect with other learners, to balance formal and informal contexts, and to mediate critical and creative ability (Cigognini et al., 2011). Dabbagh and Kitsantas developed a three-phase model of online learning which endeavoured to provide a structured framework that enables learners to develop PKM skills in a cloud based, web 2.0 environment. Respectively, these three phases emphasise (1) personal information management, (2) social interaction and collaboration, and (3) information aggregation and reflection (Dabbagh and Kitsantas, 2012).

1. At phase one, instructors seek to facilitate learners' self-regulated learning processes by encouraging them to use cloud-based technologies such as blogs and wikis and

online storage facilities to create their own individualised PLE. By guiding learners to source and create their own personalised content, and instructing them to manage such content through online bookmarks, media resources and personal journals, learners are simultaneously developing key competencies in information management, goal setting and planning.

2. Once an incipient PLE has been established, phase two introduces aspects such as social interaction and collaboration. In this phase, instructors encourage students to engage in basic sharing and collaborative activities with their peers. This may be realised by enabling a blog's comment feature, which permits instructors and peers to offer feedback, or by using a

Wiki to establish a collaborative workspace. Such social interactions with fellow learners foster informal learning communities which are based on the course topics, thereby extending the PLE from a personal learning space to a social learning space.

3. Phase three of the pedagogical framework emphasises reflexive information aggregation and management. In this phase, the instructors assist students in utilising cloud technology to synthesise and aggregate information from the first two phases in order to reflect on their overall learning experience. Such reflexive contemplation encourages students to take greater control of their PLE, customising it and personalising it around their own learning goals. This evaluation and

self-reflection is used in a cyclical manner by the student to influence their future efforts and goals, leading them to adjust and further refine their PLE and consequently academic trajectory (Dabbagh and Kitsantas, 2012).

Conclusions and Future Work

Cloud computing technology and the web 2.0 environments that it fosters hold the capacity to positively influence education both at the macro-institutional level and at the micro-level of learners' relationship with their studies. This paper has argued that by providing users with enhanced, on-demand computing services, educational institutions can be alleviated of the large financial burden of establishing and maintaining such services locally. Furthermore, cloud technology can provide researchers and

developing countries with access to computer services which would otherwise be unattainable for them. With regard to learning, cloud computing technology enables the creation of personal learning environments which facilitate self-motivated learning and collaboration between peers. Research suggests that such environments can help students to develop self-regulated learning skills, meta-cognitive faculties, positive academic identities and an increased sense of connectedness to their studies.

However, it is important to exercise due caution when envisioning the perceived impact of cloud-computing on education. Issues pertaining to privacy, ownership, reliability and legality are still often barriers which prevent institutions from fully embracing the technology. However, these issues are

becoming less severe as the technology matures and adapts to market needs. Additionally, although cloud computing technology enables the development of fertile online learning environments, the use of such environments by learners must be carefully mediated and guided by informed instructors who are sensitive to both the benefits and limitations of the technology.

With the advent of a new technology, it is often forgotten that such technology is only really as good as the people who use it; for example, see (Webb, 2010). Thus, future directions for research should not only focus on examining how cloud computing technology can transform education, but also on identifying which frameworks and pedagogical strategies will enable learners to fully reap the benefits of the cloud.

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