Technology Trends and Higher Education

In the following pages, The Hanover Research Council reviews a variety of articles regarding trends in technology in higher education and provides a brief summary of these trends and their implications.
Technology Articles

Emerging Technologies and Trends (The Horizon Report)¹

Technologies to Watch

The Horizon Report puts a close focus on key technologies that are projected to have a sizable impact on education. The report is structured in terms of which technologies will impact learning on the near-term (within the next twelve months), which will impact learning on the second adoption horizon (within two to three years), and which will impact learning on the far-term horizon (within four to five years).

This year, the Report focused on the following technologies within each time span:

**Near-term**
- Mobile computing
- Open content

**Second Adoption Horizon**
- Electronic books
- Simple augmented reality

**Far-Term**
- Gesture-based computing
- Visual data analysis

These technologies are reviewed in greater detail in the sections below.

Mobile computing

- The rise of the smartphone means that more and more people have hand-held computing devices in their pockets. These devices make it possible for people to edit documents, record video and audio, geolocate, participate in social networks, and perform assorted other tasks, virtually wherever they go and whenever they want. These devices are becoming people's main means of connecting to information, due to their portability and affordability.

- Additionally, the increasing popularity of netbooks—smaller, lighter, constantly connected laptops—and related devices like ebooks and email readers makes it possible to carry essentially an office in your backpack.

¹ http://www.educause.edu/ELI/2010HorizonReport/195400
Relevance for Teaching, Learning, or Creative Inquiry

- The rise of mobile computing makes possible a number of innovative practices in education. Students and faculty are engaging in collaborative projects in which students gather data remotely and contribute to a central repository. This is leading to restructuring of lab course scheduling, as faculty are designing experiments that students can complete remotely within a specific time frame. In computing class, designing applications for these devices has become another assignment possibility.

- The report points out assorted fields in which mobile computing has come to play a role, including chemistry, history, information technology, and medicine.

Open Content

- The continuing integration of information technology into education is also seeing a rise in the adoption of open content. Simply put, the term describes the wide and free dissemination of courseware and learning materials via the Internet. Organizations supporting this include MIT’s Open Courseware Initiative, the Open Knowledge Foundation, and the Open Content Project. However, the open content community is diffuse, and users must develop skills in finding useful resources and content evaluation in order to make use of these shareable resources.

- Relevance for Teaching, Learning, or Creative Inquiry
  - The acquisition of useful open content, in itself, is a process that engenders valuable research and source evaluation skills.

  - Making learning sources and materials widely available means that learners are able to consume the material in any way they choose. This means a significant shift in the role of the educator from a primarily pedagogical function to the role of a facilitator, in which teachers guide students toward information sources and allow them to learn at their own pace.

  - Open content projects are in progress in multiple fields, particularly art history, health sciences, and literature.

Electronic Books

- The electronic book has, with the emergence of the Kindle and similar devices, become fully mainstream. E-readers are increasing in popularity, and
publishers are making more and more titles available for download. A wide array of books is already available, including thousands of titles digitized some forty years ago by Project Gutenberg.

- The electronic book format makes it possible for a single device to carry thousands of books, each accessible at the click of a button, with more options accessible via wireless download. As the electronic book grows in popularity, the academy will need to integrate it into education.

- **Relevance for Teaching, Learning, or Creative Inquiry**
  - Previously, the technical limitations of the electronic book format and electronic readers held the format back from wider adoption. Advances in the technology, though, make it possible for academic texts to be faithfully displayed on reader devices.

  - Pilot projects with Amazon's Kindle reader are underway at Arizona State University, Ball State University, Case Western Reserve University, Pace University, Reed College, Princeton, Syracuse University, and the University of Virginia.

  - Students appreciate the ability to store and review large amounts of material in electronic form. Administrators are likely to experience reduced paper costs.

**Simple Augmented Reality**

- Simply put, augmented reality is the overlaying of digital data to real life objects and locations, an idea that has been analogized to having a Wikipedia entry for everything you see as you see it. The technology is becoming increasingly common as mobile phones become more powerful, incorporating GPS, internal compasses, and cameras.

- The technology is currently used largely for commercial and entertainment purposes, but this will ensure more widespread adoption, opening the way for educational possibilities.

- **Relevance for Teaching, Learning, or Creative Inquiry**
  - For education, gaming is the crucial application of augmented reality. Real world-based games allow educators to show relationships and connections.
• Augmented reality can also allow users to see three dimensional views of objects. This has potential applications in architecture where users could explore and manipulate detailed structure models.

• Augmented reality texts are also possible, which would provide readers with more in-depth information on topics and links to related information.

**Gesture-Based Computing**

❖ Gesture-based computing represents a sizable shift in the way that humans interact with computers. Instead of pointing and clicking, new technologies have people pinching, swiping, and even shaking their devices. The technology is largely applied to data manipulation and gaming at the moment, but it is bound to progress into wider consumer adoption in the long term.

❖ Relevance for Teaching, Learning, or Creative Inquiry
  • Gesture-based controls will allow for novel methods of interacting with data and learning objects in the classroom of the future. Projects are already in the works to implement it in medical image manipulation, sign language instruction, and surgical training.

**Visual Data Analysis**

❖ Ever-increasing computing power, coupled with graphics technology and high resolution displays has resulted in the rise of visual data analysis. The field makes use of the pattern recognition skills present in the brain to present data in a manner that leads to easy interpretation. Among the sorts of presentations are: self-organizing maps that mimic the connections between neurons for datasets; cluster maps, in which similar data clusters together; and interactive principal component analysis, which finds hidden trends in multidimensional sets.

❖ The tools are making their way out of the hard core statistical analysis fields and becoming more common in other fields.

❖ Relevance for Teaching, Learning, or Creative Inquiry
  • As the tools make their way into the mainstream, they are being used by academics in business and social research. For example, visual techniques may add a new dimension to textual analysis.

  • Applications for teaching and learning are not yet developed, but it’s easy to imagine that the technology could be, for instance, used in
instruction for undergraduate survey courses, as the technology could model complex processes in the hard sciences and economics.

- The technology has already been put into use in a number of institutions specializing in astrophysics, fluid dynamics, marine geology, and composition and rhetoric.

Key Trends

To encompass the technological realities of the time, the Horizon Report identifies key trends in the world of educational technology and the forces they believe will shape the field for at least the coming five years. This year, the trends the Report identified tended to stem from ubiquitous Internet access and the challenges and benefits such access will bring about:

- The ever-increasing availability of access to the Internet is bringing about a change in the nature of education. The role of the educator in sense-making, coaching, and credentialing will need to change or at least be more closely examined by educators as sources of information and credentialing proliferate.

- The commonness of access is also making it so that people expect to be able to work, learn, and study at their own pace. Educators will need to adapt their methods to meet the expectations of learners.

- Increasingly, cloud-based computing is becoming the norm. This means work is accessible from any number of devices at all times, with the potential to result in significant cost savings for consumers and institutions.

- Students are increasingly likely to engage in collaborative work. This is driving cross-campus collaborations between departments. It appears that the future of work is working together.

Critical Challenges

The Report also notes critical challenges facing learning organizations. In this, challenges are approached with the same mindset as emerging trends; that is: what are the challenges most prevalent over the next five years or so? The critical challenges this year were identified as:

- The academy needs to determine its role in preparing students for their future lives. The academy must encourage the use of new technologies in student learning to foster experience in research, experimentation, problem-based learning, and other forms of creative work.
The proliferation of authoring, publishing, and research technologies means that evaluation metrics must be updated to the current time. Peer review is undergoing a massive redefinition, coming to encompass means such as reader ratings, blog mentions, and retweeting.

Digital media literacy continually increases in importance, but the faculty body is lagging behind. The academy must increasingly integrate digital literacy into the practice of education.

Budget reductions are leading institutions to narrow their missions at precisely the time that they should be widening them.

A Few Technologies That We Should Know...

EDUCAUSE’s "7 Things You Should Know About" series provides a concise look at emerging technology trends, informing readers in a brief fashion of the developments most likely to have an impact on the future of technology. These technology trends are described as follows:

Cloud Computing

Cloud computing is the "outsourcing" of digital processes to remote servers. The service has existed for a while, but recent advancements in bandwidth, standard, and software technologies have made it much more reliable. As a result, institutions are increasingly sourcing data-intensive work to the cloud, saving institutional resources for more easily manageable tasks.

Implications for Teaching and Learning

- The rise of cloud availability means that smaller institutions will not have to spend as much on IT resources.
- Institutions making use of the cloud will have a whole other set of issues to consider, including privacy, security, data integrity, intellectual property management, and others.
- Cloud computing will also require IT staff to develop different skills, such as managing contracts, overseeing integration of in-house and outsourced services, and IT budget management.

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2 http://www.educause.edu/node/176856
Federated Identity Management

Perhaps best described as distributed credentialing, federated identity management may be used to help multiple institutions to increase access to their data and applications without taking on the added headache of increased user identity management.

In federated identify management systems users in a federated system sign up at their home institution, which maintains a persistent identity for them. When a user attempts to access another institution's data or applications, the remote institution verifies the user's identity and status with the user's home institution before granting access. Since the user information is hosted on the user's home institution's IT infrastructure, the remote institution doesn't have to manage additional user identities, while the home institution is able to provide all the resources of the federation of institutions while only maintaining its own user identity base. The technology is seeing adoption in medical databases, high-performance computers, and life science visualization tools, among other areas. Wider adoption will likely come as more applications are developed with this set-up in mind.

Implications for Teaching and Learning

- This sort of technology increases the potential for massive collaboration between federated institutions. Conceivably, within a federated system, large, data-intensive projects could be carried out at multiple institutions, with multiple students and faculty accessing and modifying data; all without each institution having to set up a separate identity for each user.

- This technology does raise concerns for institutions regarding data security, user verification, and unauthorized access.

3 http://www.educause.edu/node/179330
**Virtualization**

The typical server setup calls for placing one application on one machine and leaving that machine's capacity to its sole application. This typically results in vastly underused machines taking up increasing amounts of space. Virtualization is the process of making it so that one machine can handle multiple applications, and even multiple operating systems. A software component manages the machine's resources, allotting processor time for applications when they need it, and consequently more efficiently using the technology. As a result, services that used to require multiple machines now require comparatively few, and the institution's IT resources are more efficiently used.

**Implications for Teaching and Learning**

- Higher education institutions typically face strong budget constraints. Virtualization offers a way of getting more out of existing IT infrastructure while reducing power consumption.
- Virtualization also allows for greater server centralization, which results in greater security. This may, though, encounter resistance from faculty and staff reluctant to cede control over departmental servers.
- Virtualization requires retraining of existing staff or the hiring of new staff familiar with virtualization techniques and limitations.
- The tech has the potential to add real flexibility for departments and to increase security and reliability.

**DNSSEC**

The architecture underlying the Internet is incredibly open to attack. The problem is based in the Domain Name System (DNS), which directs Internet traffic with a distributed network of name servers. These servers translate text-based web addresses into the IP addresses that actually mark the site. The problem is that DNS is insecure, allowing for hackers to redirect traffic to malicious sites simply by inserting corrupt or incorrect code on servers. The solution is DNS Secure Extensions (DNSSEC), which adds security provisions to DNS to ensure that outgoing traffic is always sent to the correct servers and eliminate the risk of malicious redirection. The technology is being implemented throughout the Internet, with the .edu domain transition currently underway and the .com and .net domain transitions slated for 2011.

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4 [http://www.educause.edu/node/182646](http://www.educause.edu/node/182646)
5 [http://www.educause.edu/node/195431](http://www.educause.edu/node/195431)
Implications for Teaching and Learning

- DNSSEC compliance is a way for colleges and universities to ensure that hackers are not able to damage institutional status. Higher education institutions need to maintain a "good Internet citizen" perception, and a severe data breach can have deleterious effects on an institution's image.

- More tangibly, DNSSEC will allow institutions greater assurance that the sensitive information they keep on students and others is, in fact, secure. Institutional IT assets – email, data, etc. – are also made more secure.

- Implementing DNSSEC will require much effort by all involved parties. Organizations will need to update their DNS software, and new hardware upgrades are not entirely out of the question. DNSSEC might decrease access speeds for some users also.

Keeping the Guard Up in a Down Economy: Investing in IT Security in Hard Times

Even as the economic downturn continues, entities like the Higher Education Information Security Council (HEISC), Internet2, EDUCAUSE, and even the U.S. federal government are promoting the need for private and public institutions to take leadership and responsibility for cybersecurity.

This increasing emphasis on information technology security has important implications for higher education, whose central mission of the development and sharing of knowledge means that they face a precarious balance between information security and academic freedom. While many current college and university policies do not make the connection between good security and lower costs, this is changing as campuses find that information security is important to students, parents, donors, and other stakeholders.

While over the past decade campuses’ information security programs have evolved significantly with the establishment of information technology security departments, the development of “security reviews” of internal colleges, central administrative units, and other departments, the creation of partnerships with other entities in the higher education community and the FBI, the enhancement of security training and strategies, and the creation of oversight committees responsible for cybersecurity, many challenges still exist.

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6 http://www.educause.edu/EDUCAUSE+Review/EDUCAUSEReviewMagazineVolume44/KeepingtheGuardUpin
aDownEconom/178409
Challenges in IT Security

These challenges tend to center on the development of information policies, rather than information technologies, in the protection of information technology. In addition to a continued effort to balance customer service and academic freedom with security, colleges and universities must address the following security issues:

- **Identity Management**: Within institutions, multi-identity management approaches need to be evolved into a single identity management structure. This structure must incorporate the issuing and maintenance of credentials (e.g., password change), enabling/enforcing policies (PEP, PDP), and secure communication processes and application. Across institutions, the issue of identity management becomes even more challenging as identities across institutions must be coordinated to allow access to other institutions’ systems. Initiatives such as InCommon have been created to help institutions manage identity across institutions.7

- **Cloud Computing Security**: As cloud computing becomes more common, so too do issues of the control of security and data integrity in the “cloud.” Securities and technologies must be adopted to protect data and intellectual property stored in cloud computing systems.

- **Social Networks and Security**: Similar to the increase in the use of cloud computing systems, the popularity of social networking raises new security issues. Campuses must address issues of security and policies for environments like Facebook, MySpace, or Twitter.

- **Old Distributed Data**: Old but viable personal identifiable information (PII) data still exists on desktops, laptops, and hard drives, creating the potential for large security breaches.

- **Identity Thefts, Scam-in-a-Spam, Phishing**: It is likely that identity thieves, scammers, and phishers will become more adept at evading the security systems set up to stop these problems. As a consequence, higher education must be aware of new evasion techniques and create security controls to protect against these attacks.

- **Secure Web Applications**: Institutions must figure out how to balance the creation of useful web applications for educational purposes with the need for information security.

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7 [http://www.incommonfederation.org/about.cfm](http://www.incommonfederation.org/about.cfm)
Finally, the economic recession adds a new challenge: in the case of layoffs, how do institutions ensure that laid-off employees do not take important data and security procedures with them, intentionally or inadvertently?

**Resources for IT Security**

While this and many other challenges exist for technology leaders in higher education, at the same time there are also many resources available. The Research and Education Networking Information Sharing and Analysis Center (REN-ISAC), provides a way for information security specialists to leverage a centralized entity to provide security, while groups like the HEISC provide a peer support within a broader higher education cybersecurity community. It is the responsibility of these technology leaders – campus CIOs and other IT leaders, to lead their colleges and universities in a central security effort. By working with other members of the higher education community, the private sector, and the government, higher education can achieve the performance and security objectives necessary in the changing technological environment.

**Above-Campus Services: Shaping the Promise of Cloud Computing for Higher Education**

There are numerous economic benefits and knowledge-sharing opportunities in cloud computing models for institutions. Yet in order to achieve the benefits of cloud computing, institutions must first identify an aggregation model for IT services that suits the institution’s needs regarding which IT services should be aggregated and the governing of these services. Three models for aggregating IT above-campus services are reviewed:

- **Commercial Sourcing:** This well-known model involves three main methods for provisioning commercially aggregated IT services: Infrastructure as a Service (IaaS), Platform as a Service (Paas), and Software as a Service (Saas). Each of these solutions takes services that were initially designed to be a consumer experience and then brands it with the institution’s identity with little need for technology investment on the part of the institution.

- **Institutional Sourcing:** In this model, one or more institutions become a direct service provider to other institutions. Not surprisingly, this model is very popular among institutions that are formally members of a university or college system.

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v Consortium Sourcing: This model allows institutions to enter a consortium of services in which an institution can chose to operate its IT services itself or can chose to contract with another institution in the consortium. For example, HathiTrust\(^{10}\) and ETUDES\(^{11}\) are consortium models among institutions. However, it should be noted that consortium models have a somewhat “checkered” history in higher education, and should be approached with caution.

The Service/Model Matrix

However, no one model is perfectly suited to any institution, and often a mix of the models may be the best fit for an institution. The Service/Model Matrix may be a useful tool for institutions to use as they consider the types of IT services and aggregation models best suited for the institution. The first step in the matrix is to list specific IT services offered by the institution, then to determine the baseline condition of these services plus the three-above campus aggregation models as potential options. An example matrix is as follows:

<table>
<thead>
<tr>
<th>IT Service</th>
<th>Unaggregated Local Model</th>
<th>Aggregated Above-Campus Models</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current Baseline</td>
<td>Commercial Sourcing</td>
</tr>
<tr>
<td>Business Continuity/ Disaster Recovery Planning</td>
<td>Local</td>
<td>Institutional Sourcing</td>
</tr>
<tr>
<td>Classroom Videos</td>
<td>Pilot</td>
<td>Consortium Sourcing</td>
</tr>
<tr>
<td>Clinical Research Data</td>
<td>Local</td>
<td></td>
</tr>
<tr>
<td>DNS Backup</td>
<td>Local</td>
<td>Planned</td>
</tr>
<tr>
<td>E-mail (faculty/staff)</td>
<td>Local</td>
<td></td>
</tr>
<tr>
<td>E-mail (student)</td>
<td></td>
<td>Current</td>
</tr>
</tbody>
</table>

The end result of these types of aggregated models is to provide a type of broad, cross-campus “meta-university” in which participating institutions can share knowledge and services. This type of arrangement will most enhance IT services that are critical to education and research.

\(^{10}\) http://www.hathitrust.org/
\(^{11}\) https://myetudes.org/portal
Trends in Sourcing in Higher Education

Consortium Sourcing may be most applicable to many institutions seeking to improve the functionality of the activities outlined in the Service/Model Matrix. For IT leaders in higher education, Consortium Sourcing may provide:

- **Efficiency**: Aggregating demand and changing a technology problem into an IT service can result in cost savings for institutions.

- **Direction**: The governance of a consortium agreement has better chance of steering the provided IT services so that they reflect the needs of higher education.

- **Leverage**: The combined skills of experts across campuses in a consortium agreement can be leveraged to solve common problems.

Looking into the future of above-campus IT services, the authors propose the following actions:

- **Federated Identity**: Institutions must work together to create a federated identity and a common means of authentication and authorization of services.

- **Consortium Maker**: Higher education needs a leader to provide the legal and IT infrastructure to facilitate the creation of consortiums of above-campus IT services.

- **Staff Development**: Institutions must invest in career development and talent management for IT staff in order to train staff in above-campus IT services and skills.

- **Policy Evolution**: Finally, institutional policies should be modified to support the adoption of campus solutions, in addition to simplifying the procurement processes to facilitate the assessment of consortium offerings.

What Technology? Reflections on Evolving Services

The following is a selection on five evolving technologies selected by EDUCAUSE’s Evolving Technologies committee. Below, excerpts from the white papers on each of the technologies are presented. The full white papers are posted on the Evolving Technologies Committee website.

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Cyberinfrastructure and High-Performance Computing: Cyberinfrastructure describes the evolving access to high-performance computing and networks to support research.

Importance to Higher Education:
- High-performance computing has changed the way in which the sciences, social sciences, business, and economics conduct research.
- Many institutions have created research computing centers to support faculty research, and with the support of the National Science Foundation, high-performance computing and networking tools continue to advance.

Evolution
- The role of central IT organization in supporting research computing is growing. Yet shared governance of the IT resources allows all parties to benefit from cost-savings and shared access.

Conclusion
- CIOs and other institution leaders should become knowledgeable about any high-performance systems already on campus and should start planning to increase the use of high-performance computing to help faculty access research.
- Any campus research projects that would benefit from a centrally supported research infrastructure may provide a good start to this type of campus cyberinfrastructure.

Open-Source Learning Management Systems: Learning Management Systems (LMS) have become “mission-critical” to higher education in recent years. Blackboard is the largest commercial provider, although concerns over a monopoly have led to the creation of open-source LMS systems like Sakai and Moodle. The use of these open-source systems is predicted to grow.

Importance to Higher Education
- Open-source systems provide a low-cost way to offer LMSs that have the added benefit of allowing faculty to choose their course design and content.
- Can be updated on the academic schedule rather than the vendor schedule.

Evolution
- It is very important for the LMSs to be able to integrate with campus systems. The Moodle platform does this with little additional
programming and has options for synchronous interaction through Sloodle (Simulation Linked, Object Oriented Dynamic Learning Environment).

Conclusion
❖ Regardless of whether the institutions examine Moodle, Sakai, or other open-source products, each solution offers cost savings.

❖ However, the support costs of the systems can fluctuate depending on the institution’s commitment and layers of support.

Product Managers in IT Organizations: Product managers in higher education IT departments are becoming more prevalent.

Importance to Higher Education
❖ Product managers help IT organizations to focus on service rather than on the technology.

❖ In doing so, product managers help organizations to concentrate on large enterprise applications and the related technologies used to deliver services.

Evolution
❖ Product managers note the requirements and features of a particular product or service in a product description. These descriptions are generally used in turn as internal institutional guides.

Conclusion
❖ As higher education is asked to deliver its services to internal and external customers, product managers become increasingly necessary to help implement IT service management models for technologies and services.

Information Resource Management and Technologies for Libraries: Information resource management and technology become more important as the distribution of digital resources grows. There are a number of information resource management options available, including:

❖ Collaboration and the Cloud: The integration of cloud computing and service-based architectures for information resources has the potential to change how libraries “define collection building, share management of information resources, and provide access to those resources for their user communities.”
Semantic-Aware Applications: Semantic web capabilities include applications that gather and aggregate the context of information, and then use the context to find meaning without the need of human intervention. This capability could shift the focus of libraries from managing resources to developing semantic algorithms and lexicons that may be used to extract answers from resources.

Visualization Tools: Visual literacy skills for interpreting data and determining its authenticity becomes more important as the volume of information increases.

Personalization Tools: The tools used to organize, customize, and personalize the online information environment to fit different professional, scholarly, and research needs are expanding.

Importance to Higher Education

As the physical location of libraries grows less important, the need for capable information resource management technologies that can provide a broadly defined set of services, resources, and collections grows.

Evolution

The technologies are becoming more collaborative and adaptable at the enterprise-level, as well as being able to be integrated with teaching, learning, research, and administrative systems.

By combining services through cloud storage and cloud-enabled applications, institutions can build collaborative work environments in which information is shared.

Allows for more time to be spent on analyzing information rather than managing the mechanics of specific resources.

Conclusion

Libraries will be able to turn themselves into multi-institution service providers that share resources and staff in collaborative environments.

IT Service Management: This is defined as a set of practices that help organizations to manage their infrastructure and services to improve the performance of information technology. The focus of IT Service Management (ITSM) is on the customer’s perspective. One of the most popular ITSM frameworks is ITIL, which has expanded to provide a service life-cycle approach to service management.
Importance to Higher Education

- Can help IT managers to review services and their reliability, security and costs.

- The current political and regulatory climate may increasingly require institutions to have industry-standard frameworks for IT services and security.

Evolution

- There is an evolving set of software and services designed to allow organizations to facilitate the implementation of ITSM frameworks. This type of software includes BMC’s Remedy and FrontRange Solution’s ITSM, or ITIL Lite and ITIL Small Scale Implementation for smaller organizations.

- ITSM is still new to higher education, although Cornell, NYU, the University of Wisconsin, and Yale University have adopted ITSM practices.

Conclusion

- Larger institutions may already be investigating ITSM frameworks.

- IT leaders should learn about ITIL and other frameworks in order to begin the discussion of how these frameworks might be adopted in their institution.

Ten Years of Evolving Technologies

The past decade of research from the Evolving Technologies Committee has uncovered some interesting trends in technologies. As the years have passed, interest has shifted from mobile devices and supporting wireless infrastructures, to cybersecurity and the development of cloud computing and open-source systems. Overall 62% of the technologies can be classified as those focused on “managing the enterprise,” 28% of technologies can be classified as “teaching and learning technologies,” and 10% can be classified as “e-research” technologies.

The ECAR Study of Undergraduate Students and Information Technology, 2009

Since 2004, EDUCAUSE’s ECAR Study of Undergraduate Students and Information Technology has examined the ways in which technology affects the college experience.

Students are surveyed as to what technology they own, how they use technology in- and out-of school, how they feel technology is affecting their learning experience, and their preferences in the use of information technologies in courses. The study

13 http://net.educause.edu/ir/library/pdf/ers0906/rs/ERS0906w.pdf
includes a review of the literature, a web-based quantitative survey of college and university freshman, student focus groups, student comments to open-ended questions, and a comparison of longitudinal data from 2006, 2007, 2008, and 2009. In the most recent year, the focus topic was on internet-capable handheld devices. The key findings from the survey are as follows:

**Student Ownership and Use of Computers**

- Respondent ownership of computers has remained steady at about 98% for the past four years, but the number of students with laptops has increased dramatically.

- Despite the economic downturn, students are entering school with newer equipment.

- The use of basic technologies, such as library websites, presentation software, and downloading music is very broad among the majority of students. Music downloading in particular has grown in popularity, increasing from 71.4% in 2006 to 83.5% in 2009.

- Content creation through Web 2.0 user-driven sites is popular among slightly less than half of the respondents.

**Interactive Communication Tools**

- Interactive communication tools like text messaging and instant messaging has changed the ways in which college students connect with the world. Text messaging is used by almost 90% of the respondents.

- Respondents between 18-19 years used social networking sites the most, while respondents aged 20-24 were only slightly less active. Over 90% of students from each group use social networking sites.

**Technology Being Used in the Quarter/Semester of the Survey**

- The majority of students said they use the library website, course or learning management system, and presentation software like PowerPoint.

- Almost 50% of the students said they use spreadsheets like Excel.

- Less commonly used technologies include wikis, instant messaging in courses, graphics software, blogs, and programming languages.
While students used podcasts and video- and audio-creation software for personal use, then were less likely to use these technologies for academic purposes.

How Students View Their Own Technology Adoption and IT Skills

- Over the past view years, respondents’ views about their own technology adoption status (innovators, mainstream adopters, late adopters, and laggards), have formed a tradition bell curve, with about 50% of respondents identifying themselves as “mainstream adopters.”

- Males were more likely than females to consider themselves to be “early adopters” or “innovators.”

- Most of the students indicated that they had confidence in their skills with presentation software, spreadsheets, course and learning management systems, and college and university library websites. Confidence was lower in skills like using graphics software and on the ability to conduct computer maintenance activities.

- 8 out of 10 students were considered themselves to be internet-savvy, and almost half rated themselves as experts. However, students were less able to evaluate the reliability and credibility of online sources.

Courses and Learning Management Systems

- The number of respondents using learning management systems increased from 79.7% in 2006 to 91.0% in 2009.

- Students generally have positive perceptions of learning/course management systems.

Student Perceptions of IT in Courses

- Fewer than half of the respondents reported that all or almost all of their instructors use IT effectively, or have the adequate IT skills needed for carrying out instruction. Just over a third said that instructors provide them with adequate training to use the IT required by their courses.

- Students were most positive about IT’s impact on convenience; while about 30% thought IT improved their learning, and about 50% said that the IT used in their courses will have adequately prepared them for the workplace.
Undergraduates and the Mobile Revolution

❖ About half of the respondents own an internet-capable handheld device and almost 12% plan to purchase one in the next year.

❖ More than a quarter of the respondents owned handheld devices and used them to access the internet weekly or more often. Less than 1% owned devices but used them to access the internet monthly or less frequently. About 30% either currently owned a device but never used it to access the internet or didn’t have internet capabilities. Finally one third of the respondents didn’t own a device and didn’t plan to buy one.

❖ Cost and alternative ways to access the internet were listed as reasons for not owning a mobile device.

❖ The majority of students who owned the devices used them for checking information such as news and weather, while fewer used them to get directions or find maps. Email and text messages were also common responses.

Mobile Devices in the Academic Environment

❖ Most of the respondents noted that if mobile devices were used in class, it was for non-academic purposes.

❖ Half of the students felt that mobile devices were disruptive in the classroom and that instructors should forbid their use.

❖ The top three institutional services that respondents’ used their mobile devices for were e-mail, student administrative services, and course or learning management systems.

Emergency Notification

❖ Respondents noted that they preferred the use of text messaging for emergency notification.

❖ However, text messaging does have disadvantages in emergency notification, including “inherent design problems, the opt-in process, character limits, and vulnerability to abuse.”
Conclusions

While the study found that today’s students are very comfortable with technology, most want to see a balance between the use of technology and personal interactions in the academic environment.

Bottom Up and Top Down: Making IT a Key Part of the Campus Sustainability Effort\(^\text{14}\)

Sustainability at Indiana University

Indiana University (IU) provides an excellent example of a successful sustainability initiative at a time when the importance of long-term green practices are foremost in the spotlight.

In 2007, IU put together a task force to examine issues of sustainability and develop a long-term sustainability framework. With the lead of a project champion, a strategic plan for sustainable IT was developed. The early days of the sustainability initiative focused on a grass-roots level commitment to campus sustainability with the support of the Cabinet and other leaders who turned the initiative into strategic plans. This dual approach highlights the three levels necessary for sustainability in higher education:

- Policy and planning
- Operations
- Personal Practice

Operations and Collaboration

These three levels require a multidirectional approach in which everyone on the campus is involved in the effort. In addition, institutional responsibilities for sustainability must be outlined. At an operational level, institutions should examine their practices to determine where energy savings might be initiated. For instance, at IU it was common practice to leave computer equipment on after hours in order to allow parts to be patched or updated. In response, an energy reduction pilot program was initiated in which the IT staff adjusted the input/output system settings of the desktop computers to save energy, and measured and aggregated the savings from this change. From this simple change, other operational measures were undertaken to save energy in computer usage.

\(^{14}\) http://www.educause.edu/EDUCAUSE+Quarterly/EDUCAUSEQuarterlyMagazineVolum/BottomUpandTopDownMakingITaKey/182040
Widening the Scope: Cross-University Initiatives

In order to appeal to a broad base, IU built engagement in the sustainability initiative through an appeal to the cost savings achieved from saving energy. Furthermore, IU brought a specific energy-saving solution – virtualization – to the level of policy and strategic direction. This provided the leverage needed to allow the university system to consolidate, standardize, automate, and virtualize its intelligent infrastructure initiative. This initiative eliminated the need for replication of systems, servers, equipment, software, and heating and cooling equipment. It also helped to create a new, more energy efficient IU Data Center. The intelligent infrastructure enables IU to adapt easily to changes in technology while also creating cost savings.

Widening the Scope: The Commercial Cloud

The consolidation effort under the intelligent infrastructure also enabled IU to take advantage of commercial cloud computing.

Community Involvement

As large part of this effort centered on the involvement of the entire community in the effort. For instance, the institution instituting free waste recycling days that involved IU, local businesses and schools in a recycling collection effort. Logistics representatives from Apple helped to hire the transportation and labor to aid in the effort. These “eWaste Recycle Days” helped to start the community conversation about sustainability. Yet even as the community was involved the effort was supported through the communication of the measurable results of the effort on the institution’s bottom line.

Looking Into the Future

Next steps for the effort involve:

- Engage people by building a culture of awareness
- Continued education and building on successful practices
- Build participation in the effort into the University policy
- Consider other areas where IT can enable cost savings (e.g. digitized print sources and teleconferencing)
Climate Change and Higher Education\textsuperscript{15}

The Science of Climate Change

Scientists have shown that the current human-induced rate of increase of CO\textsubscript{2} is more than 100 times faster than the rate at the beginning of the agricultural revolution, 10,000 years ago. This rise in the level of CO\textsubscript{2} already is having a major impact of Earth’s climate, as demonstrated by the rapid melting of the Arctic Sea ice. Additionally, unlike other environmental issues, such as acid rain, polluted waterways, and the Antarctic ozone hole, the increases in CO\textsubscript{2} concentrations is “effectively irreversible on a human timescale.” If governments and public and private entities do not place restrictions on emissions in this century, scientists predict that this problem will exacerbate, with the potential to triple the atmospheric CO\textsubscript{2} levels from the pre-industrial level by 2100.

Regulation and the Potential Impact on Higher Education Institutions

While the U.S. Congress and the Environmental Protection Agency (EPA) have recently developed a variety of initiatives aimed at carbon regulation, many states, provinces, and nations have developed their initiatives with a more direct impact. For example, the Province of British Columbia was recently the first jurisdiction in North America to introduce a carbon tax and to mandate carbon neutrality for all public-sector institutions. This includes hospitals, colleges and universities, schools, governments, etc. If these public institutions fail to become carbon-neutral, they must purchase carbon offsets from the Pacific Carbon Trust (PCT). Within the U.S., California’s Assembly Bill 32, now being implemented, requires a reduction of greenhouse gas (GHG) emissions in the state to 1990 levels by 2020 and to 80\% below 1990 levels by 2050. In response, the ten-campus University of California system has committed to the more ambitious goal of reducing the system’s GHG emissions to 2000 levels by 2014, with the goal of becoming carbon neutral as soon as possible.

In order to meet this goal, the University of California system measured the emissions of all ten campuses in 2008 and reported these levels to the California Climate Action Registry.\textsuperscript{16} Each campus also developed its own climate action plan: for instance, the University of California San Diego became the first west coast university to join the Chicago Climate Exchange (CCX), a North American voluntary – but legally binding – cap-and-trade emission trading system.\textsuperscript{17}

\textsuperscript{15} http://www.educause.edu/EDUCAUSE+Review/EDUCAUSEReviewMagazineVolume44/ClimateChangeandHigherEducation
\textsuperscript{16} http://climateregistry.org/
\textsuperscript{17} http://www.chicagoclimatex.com/
National Initiatives and Higher Education

At the national level, the U.S.’s proposed Waxman-Markey cap-and-trade bill would measure the GHG emissions of regulated entities and then would require these entities to decrease their emissions over time. For higher education, this bill would be mostly likely to affect campuses that have their own power plants, although campuses that purchase their power from a utility could see an increase in costs. While it is still early to estimate the cost impact of the cap-and-trade bill on higher education, experts predict significantly raised costs for college and university campuses that do not make efforts to balance their carbon portfolios.

Cyberinfrastructure and Sustainability

As climate awareness and concerns over the cost impacts of the Waxman-Markey bill rise, colleges and universities are increasingly undertaking assessments of their GHG emissions and cyberinfrastructure. This is particularly true at large research institutions, where cyberinfrastructure can be a dominant contributor of CO₂ emissions, especially if the electricity for data centers and local clusters is powered by coal.

Furthermore, while exact data is difficult to obtain because most campuses do not currently track aggregate electrical consumption, studies have shown that more than 30% of an organization’s energy consumption can be attributed to personal computers and their accoutrements. While up until recently the utility costs for campus IT operations have remained largely out of the public’s interest, as higher education becomes increasingly aware of the impact of cyberinfrastructure on costs associated with electricity, cooling, and carbon offsets, the need for greener solutions will also increase. Looking into the future, campuses must find green solutions that accommodate demands for new applications and high-performance computing and networks.
Conclusions

The technology articles reviewed in this report reveal a number of interesting trends regarding the most influential technologies for education, challenges and opportunities for higher education information technology, and trends in student learning.

The literature indicates that trends in technology are focused on the widespread availability of the internet and its effects of technology usage. For instance, mobile devices are having a huge impact on the way students interact with technology in and out of the classroom, while internet technologies like cloud computing and open-content are providing new opportunities for cross-institutional collaborations and information sharing at a low cost.

Yet a number of challenges also have risen from ubiquitous internet access and its related technology devices. Many of these challenges are focused on information technology policy rather than on the technologies themselves. For instance, information technology and cybersecurity issues have caused many institutions to revise their technology policies to adapt to changes in computing. While solutions like federated identity management and DNSSEC, or initiatives like REN-ISAC, InCommon, and HEISC are available to help institutions adopt new security procedures, given the rapid pace of technology, it may be difficult for institutions to stay on top of security solutions. Additionally, institutions are finding that the balance between the principals of academic freedom and information security may be a tricky one to achieve.

Associated with this rapid pace of technological change are challenges related to preparing students for the future with experience in research, experimentation, digital media literacy, and information evaluation. Yet at the same time, the economic downturn is forcing institutions to reduce their budget in these areas, even as students feel that most of their instructors do not adequately use technology in their courses nor adequately train students to use the required course technologies.

Finally, the growing concerns regarding sustainability and energy consumption provide a host of new challenges for colleges and universities as they seek to comply with state and Federal energy regulation and in the case of some, as they strive to become leaders in carbon neutrality. Examples like Indiana University’s sustainability initiative and the University of California Systems’ carbon neutrality and emissions goals may be valuable for institutions seeking to change their cyberinfrastructure and energy consumption habits.

Yet even with these challenges, a great number of opportunities exist for higher education. High-performance computing promises to change the capacities of research forever, just as new IT service management frameworks and information
resource management technologies allow institutions to improve their knowledge-sharing, resource maintenance, and customer service functions. The growth of open-source learning management systems carry forth this trend of collaboration and shared resources across higher education to decrease costs and improve functionality.

Finally, the students that belong to each college or university provide a host of new opportunities. More adept and comfortable with technology than their predecessors, today’s students provide institutions with a population willing and able to learn and adapt to new technologies and policies, while at the same time capable of providing the brainpower needed to continuously improve the use of technology in an educational setting.
Project Evaluation Form

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