ECAR Study: Trends in Wireless Communications in Higher Education

Seminars on Academic Computing

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IDC
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Overview

• Introduction/Research Goals
• Methodology
• Current Solutions/Plans
• The Implementation Process
• Assessment of Success
• Implications/Conclusions
Research Goals

• Assess the current state and rate of implementation of wireless data communications in higher education
• Look in detail at problems and solutions associated with wireless networking in different institutions
• Assemble information necessary to answer key wireless networking questions:
  – Where are we now?
  – Where are we going?
  – What have we learned?
Methodology

• Quantitative and qualitative research for comprehensive picture of wireless LAN activity
• Online survey of EDUCAUSE institutions Q4 ’01
• 392 responses by December 12 deadline
• Detailed phone/e-mail follow-up interviews conducted Feb/March 2002 with 17 representative institutions
• Personal onsite visits and discussions conducted with 6 institutions previously interviewed in depth
• Formal case studies prepared
Survey Respondent Demographics

- Two-thirds of the respondents are from the Baccalaureate, Masters, and Doctoral categories.
- Response rates for these categories run from 25% to 30% (28% average).

### Number of Respondents

<table>
<thead>
<tr>
<th>Professional Specialty</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doctoral</td>
<td>71</td>
</tr>
<tr>
<td>Masters</td>
<td>96</td>
</tr>
<tr>
<td>Baccalaureate</td>
<td>86</td>
</tr>
<tr>
<td>Professional Specialty</td>
<td>47</td>
</tr>
<tr>
<td>Associate</td>
<td>23</td>
</tr>
<tr>
<td>All Other</td>
<td>21</td>
</tr>
<tr>
<td>Canada</td>
<td>27</td>
</tr>
</tbody>
</table>

### Carnegie Category

<table>
<thead>
<tr>
<th>Carnegie Category</th>
<th>Educause Members</th>
<th>Respondents</th>
<th>% of Members</th>
<th>% of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doctoral</td>
<td>240</td>
<td>80</td>
<td>17%</td>
<td>20%</td>
</tr>
<tr>
<td>Masters</td>
<td>387</td>
<td>99</td>
<td>28%</td>
<td>25%</td>
</tr>
<tr>
<td>Baccalaureate</td>
<td>285</td>
<td>88</td>
<td>20%</td>
<td>23%</td>
</tr>
<tr>
<td>Professional Specialty</td>
<td>49</td>
<td>11</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>Associate</td>
<td>287</td>
<td>48</td>
<td>20%</td>
<td>12%</td>
</tr>
<tr>
<td>All Other</td>
<td>153</td>
<td>36</td>
<td>11%</td>
<td>9%</td>
</tr>
<tr>
<td>Canada</td>
<td>153</td>
<td>36</td>
<td>11%</td>
<td>9%</td>
</tr>
<tr>
<td>Total</td>
<td>1401</td>
<td>392</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

N=392

*Trends in Higher Education Wireless Communications*
Phase Two Qualitative Research Participants

- College of Mount Saint Joseph
- Dartmouth College
- Duke University
- Florida State University
- Harvey Mudd College
- Indiana University
- Maricopa Community College
- Middle Tennessee State
- Middlebury College
- Oberlin College
- Rockland Community College
- University of California Berkeley
- University of California San Diego
- University of Pennsylvania
- University of Toronto
- University of Wisconsin Madison
- Wake Forest University

Majority of Doctoral Institutions
Mix of Public/Private
Mix of Regions
Implementation Rates

- 60% of respondents have moved forward with wireless networking, although implementation is usually in stages
  - The rate is highest in Doctoral (75%) and “other” (79%)
- Almost all other institutions are planning wireless or intend to implement wireless

![Graph showing implementation rates.]

- Implemented comprehensive: 7%
- Implemented limited: 52%
- Planning - pilot implementation: 17%
- Planning - no pilot yet: 8%
- Intend to implement: 10%
- No plans to implement: 6%

N=392

*Trends in Higher Education Wireless Communications*
Year of Implementation

- Three-quarters of those implementing wireless networks have done so since the start of 2001 (includes those with pilot implementations)

N=299

Trends in Higher Education Wireless Communications
Multiple Wireless Initiatives & Interoperability

- Just over half of the respondents have multiple wireless initiatives
  - The larger the institution (FTE), the more likely that there are to be multiple initiatives
- The majority (73%) of respondents with multiple initiatives have established standards for interoperability
  - This is higher for those in the implementation stage (79%) that for those still planning (54%)
  - The IT department usually sets the standards (91%)

![Bar chart showing the percentage of respondents with one, two, or three or more wireless initiatives across different FTE categories.]

N=329
**Scope of Implementation**

- Most current wireless implementations are in specific buildings
  - The larger the institution (FTE), the more likely it is to have a specific location implementation
  - Smaller institutions (<10,000 FTE) are more likely to have a campus-wide implementation
- Of the institutions that have location-specific implementations today, half plan to expand to campus-wide
- The implication is that institutional roll outs are phased

![Pie chart showing the distribution of different types of wireless implementations:Specific building/location (23%), Campus-wide (23%), Other (1%), Specific buildings (53%). N=299]
Reasons for Wireless Implementation

• Most institutions implemented their wireless network as a complement to current wired network operations
  – Dartmouth College: “We wanted to provide network access literally anywhere, indoors or outdoors.”

• Another reason for implementing wireless is to augment wired networks to provide comprehensive network access
  – Maricopa Community Colleges: “The college built a new science building where classrooms and labs were built around a central storage room. The building’s layout made wiring the rooms for network access very expensive. We chose to try wireless because it was more cost effective.”
  – University of Wisconsin Madison: “We had run out of space for additional computer labs. We were trying to find ways to reduce the long wait lines in our public computing labs. Since we knew 25% of the students who owned a computer had a laptop, we wondered if they would use a wireless area instead of a lab.”

• Others feel wireless represents a means to meet future computing needs
  – Wake Forrest: “Wished not to be left behind.”
  – Florida State University: “The College of Law and MBA program in the College of Business wanted to deploy a laptop/wireless initiative. Both programs indicated this was becoming the norm for teaching in their respective disciplines to benefit students and faculty.”
  – University of California - San Diego: “To provide new and better networking services, especially in public areas and for laptops and PDA’s...the need for ‘Internet Everywhere’.”
  – Indiana University: “Wireless networking is rapidly reaching maturity and its deployment at universities has the potential for radically changing the way they do business. Potentially most significant is that no longer will students and faculty be bound by needing to connect to a fixed network connection in order to access network resources. Wireless networking frees them from the tyranny of place and allows them to work anywhere on campus with a notebook computer and a simple wireless modem.”

Based on interviews
Comprehensive Implementation

- A few institutions started with a comprehensive implementation:
  - College of Mount St. Joseph: “I wanted anytime/anyplace computing.”
  - Dartmouth College: “We chose to cover everything because we saw academic, administrative, and "daily-living" value in a total wireless overlay. Technically, we'd already experimented with making some areas wireless (school of engineering, computer science, some library locations, student union building, some student eateries, and the central campus green).”

- Or evolving to comprehensive access:
  - Harvey Mudd College: “IT chose a limited implementation to meet specific requests, mostly requests for convenience. We have a “comprehensive” wired infrastructure and thought wireless would augment it for specific teaching/learning situations. However, people found the convenience compelling so we have a much more comprehensive wireless net than we had anticipated. All classrooms, faculty offices, labs, the library, study and project space, the dining hall, the activities center, “common” areas, and courtyards are or soon will be covered. In addition, we have coordinated our effort with other members of the Claremont Colleges so that students, faculty and staff, can also access the wireless network from similar areas on the other campuses. Finally, thanks to fortuitous circumstances (a tall building and a gradually upward sloping residential area off campus where several faculty and staff live), we installed an antenna to provide wireless access to a significant residential area.”
Outdoor Use

- Three-quarters of current wireless implementers have outdoor use or are planning outdoor use
  - The mean percentage of campus coverage (those with outdoor use) is 25%, although the median is only 10%. Smaller institutions (<10,000 FTE) tend to have higher coverage
  - The mean percentage of campus coverage will increase to 52% in 24 months (median 50%)

![Bar chart showing average campus coverage from 2001 to 2003]

- Outdoor use now: 54%
- Outdoor use planned: 22%
- No outdoor use planned: 24%

N=299

*Trends in Higher Education Wireless Communications*
Buildings with Coverage

- Libraries have the highest coverage of all building types, with coverage planned by most respondents in 24 months
- Classrooms/lecture halls will also have very high coverage
- Research center coverage is highest at Doctoral universities (60% expected in 2003)
People Using Wireless Networks

- Undergrads are the greatest users of wireless networks, followed closely by faculty
  - Use by all categories of users is highest at doctoral universities, including 80% use by grad students/researchers
  - Percent use across all categories decreases successively for Masters, BA/BS, and AA institutions

![Bar chart showing the percentage of respondents mentioning each category.](chart)

- Undergraduates: 77%
- Faculty: 73%
- Administration: 53%
- Graduate students*: 44%
- Other: 6%

*Graduate Students Includes researchers

N=299

Trends in Higher Education Wireless Communications
Departments Using Wireless

- Institutions using wireless say Computer Science, Physical Science and Business are the leading departments using wireless
- Doctoral Universities have the highest percentage of use by most departments; Associates colleges often have the lowest

<table>
<thead>
<tr>
<th>Department</th>
<th>% of respondents saying department using wireless</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Science</td>
<td>38%</td>
</tr>
<tr>
<td>Physical Sciences</td>
<td>33%</td>
</tr>
<tr>
<td>Business</td>
<td>32%</td>
</tr>
<tr>
<td>Languages/History</td>
<td>23%</td>
</tr>
<tr>
<td>Social Science</td>
<td>21%</td>
</tr>
<tr>
<td>Engineering</td>
<td>21%</td>
</tr>
<tr>
<td>Math</td>
<td>18%</td>
</tr>
<tr>
<td>Medical</td>
<td>10%</td>
</tr>
<tr>
<td>Law</td>
<td>10%</td>
</tr>
<tr>
<td>Other</td>
<td>39%</td>
</tr>
<tr>
<td>Don't know</td>
<td>11%</td>
</tr>
</tbody>
</table>

N=299

Trends in Higher Education Wireless Communications
Devices Accessing Wireless Networks

- Mobile PCs are the leading device type accessing wireless networks, followed by desktop PCs
- PDAs and handheld devices will be added by many institutions
- The largest institutions (20,000+ FTE) are the most likely to be adding device types, and will lead in the addition of all device types

**Bar Chart:**

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Now (%)</th>
<th>Adding (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile PCs</td>
<td>94%</td>
<td>6%</td>
</tr>
<tr>
<td>Desktop PCs</td>
<td>46%</td>
<td>14%</td>
</tr>
<tr>
<td>PDA</td>
<td>39%</td>
<td>27%</td>
</tr>
<tr>
<td>Handheld devices</td>
<td>9%</td>
<td>22%</td>
</tr>
<tr>
<td>Cell phones</td>
<td>15%</td>
<td>15%</td>
</tr>
<tr>
<td>Other</td>
<td>2%</td>
<td>2%</td>
</tr>
</tbody>
</table>

N=299

Trends in Higher Education Wireless Communications
Wireless Technologies Supported

- 802.11b/WiFi is the dominant technology today, and will continue to be the most used technology 24 months from now, but use will decrease significantly.
- But 802.11a will nearly equal 802.11b in two years on campuses.
  - Those switching most quickly to 802.11a will be Doctoral Universities, followed by Masters Universities; Baccalaureate and Community Colleges will lag in making the switch.
- 802.11g and Bluetooth will also be used significantly.

![Bar Chart]

% of respondents mentioning technology

- 802.11b: 90%
- 802.11a: 53%
- 802.11g: 25%
- Bluetooth: 18%
- Broadband: 6%
- Others: 3%
- Don't know/NA: 13%

N=299

Trends in Higher Education Wireless Communications
Technical Solutions Used

• 802.11b predominates among all interviewees
• Many plan to incorporate 802.11a
  – University of Pennsylvania: "We have 802.11b deployed. Interoperability among vendor products is good, performance is acceptable for most applications. 802.11a and 802.11g products are not widely available yet. We are interested in 802.11a, partly in order to gain higher throughput, but mostly to get out of the crowded 2.4 GHz spectrum."
  – Indiana University: “802.11b now, with plans for 802.11a as it becomes available. We will deploy the “a” technology when a viable product comes on the market, provided IBM (the supplier of our laptops) also adopts it.”
• Few expressed concerns about lack of 802.11b and 802.11a capability
  – Middle Tennessee State: “We’d deploy 802.11a first as a wireless backbone for remote AP connectivity; then possibly offer as a client connectivity option but we won’t/can’t alienate our 802.11b customer base.”
• Others cite cost factors
  – Maricopa Community Colleges: “802.11g sounds good because you don't have to switch out 802.11b equipment out. However, '11b' equipment is getting really inexpensive. It is a commodity and we can expand our wireless network more economically by sticking with '11.b' equipment.”
  – University of California - Berkeley: “We will deploy 802.11a when we feel it has matured enough to be reliable, and the costs are such that we can reasonably replace the equipment on a standard 3 or 4 year life cycle.”
Encryption/Authentication Levels

- Respondents are using a wide variety of encryption/authentication levels, led by Wired Equivalency Privacy (WEP: 1.6 average)
- Variety of factors at work, expect continuing refinement

<table>
<thead>
<tr>
<th>Wireless Encryption/Authentication Level</th>
<th>% of Respondents Using</th>
</tr>
</thead>
<tbody>
<tr>
<td>128 Bit Wired Equivalency Protocol (WEP)</td>
<td>33%</td>
</tr>
<tr>
<td>40-Bit Wired Equivalency Protocol (WEP)</td>
<td>17%</td>
</tr>
<tr>
<td>Firewall</td>
<td>24%</td>
</tr>
<tr>
<td>Remote Authentication Dial-in User Service (RADIUS)</td>
<td>18%</td>
</tr>
<tr>
<td>IP VPN (3-DES IPSec)</td>
<td>14%</td>
</tr>
<tr>
<td>Wireless Vendor Proprietary Solution</td>
<td>14%</td>
</tr>
<tr>
<td>Extensible Authentication Protocol (EAP) 802.1x</td>
<td>5%</td>
</tr>
<tr>
<td>3rd-Party Hardware/Software Security Solution</td>
<td>5%</td>
</tr>
<tr>
<td>Kerberos</td>
<td>3%</td>
</tr>
<tr>
<td>Advanced Encryption Standard (AES)</td>
<td>2%</td>
</tr>
<tr>
<td>Other</td>
<td>6%</td>
</tr>
<tr>
<td>None</td>
<td>18%</td>
</tr>
</tbody>
</table>

N=299
Encryption/Authentication
Wired Equivalency Privacy (WEP)

• Only 22% of those using WEP force changing of encryption keys on a regular basis
• Just over one-third of WEP users plan to replace WEP with another solution
  – 23% will replace it with EAP 802.1x draft
  – 13% will replace it with another solution

N=139
Application Encryption /Authentication Enforcement

• Just over half of the respondents enforce application encryption/authentication
  – Web-based SSL is the leading level enforced
  – Baccalaureate colleges have the least enforcement, only 35%

N=299
Security Solutions

• Authorization/Authentication/Accounting
  – In the planning stages for most: some solutions: VPNs, 802.1x or centralized authorization
    • University of California San Diego: “Users are required to login with ID and password when they first access the wireless network. If they are UCSD faculty, staff, or students they can also register their Ethernet address.”
    • College of Mount St Joseph: “W2K network logins to access the network and W2K-based network resources, separate logins for WebCT and web registration. Key resources are also either behind a firewall or in a DMZ.”

• Access
  – RADIUS is used by some, LDAP is planned by Florida State University, University of Pennsylvania and Harvey Mudd College require MAC address registration for access

• Encryption
  – Several institutions don’t use encryption, others use 128 WEP
  – Others aren’t so sure
    • University of Pennsylvania: “We recognized weaknesses in WEP since the very start. We don’t see the point in using WEP, not only because it is weak in its current form, but because higher-layer security may be more appropriate and may apply better, wired or wireless.”
    • Indiana University: “Flawed - use VPN.”
Key Wireless Network Challenges Faced

- Security and end-user support challenges are most frequently cited. (1.7 cited on average)
Security Issues

- **Most worry about security, few could outline specific incidents**
  - Wake Forest: “Security has not yet been a problem. When it develops, it could be immense.”
  - Florida State University: “Student privacy, identity theft, and fraud concerns are potential problems. No special problems as yet, however, we see a significant exposure for abuse and misuse.”
  - Middle Tennessee State University: “An unbendable requirement was for only authorized users to use the wireless network. Would not want to offer ISP service to the neighborhoods around campus. However, WEP isn’t too secure and anyone with the same WEP key can sniff traffic, so we encourage SSL/SSH use and “safe surfing”.”
  - University of California San Diego: “However, given the nature of wireless networks, we continuously stress that the clients and the servers need to make sure that they use secure mechanisms (e.g., SSL, encryption) if they want to protect the content of the transmissions.”
  - Mount St Joseph: “Security is important. We are especially concerned about talented hackers grabbing a network login and password or a credit card number “out of the air.”
  - Duke University: “Very important. RF sniffing of major concern.”
Security Issues

• Not all think it is a wireless-specific issue
  – University of Pennsylvania: “It does not matter whether the data is transmitted over wired or wireless - the data itself has to be encrypted. You can tap in either transmission way.”

• Location plays a role in security concerns
  – University of Pennsylvania: “The potential for unauthorized access to wireless networks, especially in a large urban campus, is very high.”
  – Middlebury College: “Security is not an issue at present because of limited deployment; in remote rural location, security not as high a priority as in urban environment, but we anticipate there could be snooping and attempts at interception.”

• Most felt unauthorized access was not a problem
  – Indiana University: "Not now – that we require VPN cloud authorization.”
  – University of California Berkeley: “That’s what the Vernier access managers do for us (that and support roaming.)”

• Others weren’t so sure
  – University of Pennsylvania: “It’s impossible to know it’s a problem until threatening email or other offensive or illegal activity originates from our networks, and we find ourselves unable to comply with law enforcement who ask us to track down the offending user.”

Based on interviews
How Wireless Cards Are Obtained

- The majority of institutions allow students to choose a card on their own (72% when adjusted for none needed and don’t know)
- Doctoral universities (45%) and large institutions (55%) are the most likely to offer a choice of self-purchase or obtaining from the institution
- Only 13% say they control how the card is obtained

<table>
<thead>
<tr>
<th>How Students Obtain Cards</th>
<th>% of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase on their own</td>
<td>29%</td>
</tr>
<tr>
<td>Obtain from institution or on their own</td>
<td>26%</td>
</tr>
<tr>
<td>Must purchase from institution</td>
<td>6%</td>
</tr>
<tr>
<td>Given card at no additional cost</td>
<td>5%</td>
</tr>
<tr>
<td>Must purchase from specific college/dept.</td>
<td>2%</td>
</tr>
<tr>
<td>Other</td>
<td>8%</td>
</tr>
<tr>
<td>None needed (no student access)</td>
<td>13%</td>
</tr>
<tr>
<td>Don’t know/no answer</td>
<td>11%</td>
</tr>
</tbody>
</table>
Notebook PC Requirement

• Most higher education institutions do not require students to have notebook PCs
• Only 18% say they require notebook PCs (n=299)
  – 13% say some colleges/disciplines require notebooks; this is highest for doctoral universities (27%)
  – Only six percent require notebooks of all students; most of these are small (<5,000 FTE) and/or private
• Of those requiring notebook PCs, over half require wireless access, for all students (31%) or for some colleges/disciplines (25%) (n=55)
• Institutions not requiring all students to have notebooks estimate an average of 18% of students have notebooks (n=242)
  – The percentage is lowest at Associate (10%) and public (13%) institutions
• Overall, an estimated 22% of students have access to wireless networks at responding institutions (n=299)
Access to Printing from Wireless Networks

- Users with wireless access are able to print from the wireless network at about two-thirds of responding institutions; higher (about three-quarters) at institutions that have already implemented wireless networks
  - Where printing is available, most often users can select from (several) distributed printing devices

![Pie chart showing distribution of printing options]

- No network printing: 26%
- Central printer for all: 6%
- Designated printer only: 16%
- Other: 5%
- Several distributed devices: 43%
- Don't know / no answer: 4%

N=299
Wireless Network Maintenance, User Support

- End users of wireless networks are mostly (89%) supported by the same help desk that supports the wired network
  - Only three percent have a special help desk for wireless
- In almost all institutions (96%), the IT group that supports the wired infrastructure also supports wireless
  - Only two percent have a wireless team, all at doctoral or masters universities

N=299
Problems with Inappropriate Students Access

• About one-fifth (21%) of institutions that have implemented wireless networks report that there is a problem with students using wireless access during class/lecture time for non-pertinent content (n=234)

• The percentage is similar by all institution types
Planning Process
Groups Initiating

- IT departments are the leading initiator of wireless, but many other groups are also involved (Other groups are potentially lower than actual, as most respondents are from IT)
Planning Process
Groups Involved in Planning and Implementation

- IT departments high nearly universal high-involvement in planning and implementing wireless networks
  - A few other groups are frequently moderately involved

![Bar chart showing the percentage of respondents mentioning various groups involved in planning and implementation.]

- **IT department**: 94% high, 4% moderate
- **Library**: 12% high, 41% moderate
- **Administration**: 9% high, 33% moderate
- **Specific college/dept.**: 19% high, 23% moderate
- **Faculty**: 10% high, 29% moderate
- **System vendor**: 10% high, 15% moderate
- **Students**: 9% high, 16% moderate
- **IT Vendor**: 3% high, 13% moderate
- **Comm. Provider**: 6% high, 12% moderate
- **Research Center**: 4% high, 6% moderate

N=329
Planning Process

• Wireless network planning mirrors the wired planning process at most institutions

• At most institutions, IT interacts with schools/departments as needed
  – Duke University: “Student and faculty committees are updated regularly and consulted for recommendations on new deployments.”

• IT controls the entire planning process at others
  – Wake Forest University: “All wireless use conforms to the specifications promulgated by the IT staff and endorsed by the faculty committee.”
  – Florida State University: “Our new wireless policy asserts central control and management of the WLAN. The policy addresses the need for coordination and consultation with the customer community.”
  – University of Pennsylvania: “Central networking provides the networks, wired and wireless. The schools order services from the central networking organization.”

• A few have renegade wireless networks
  – University of Wisconsin - Madison: “Some schools and colleges are putting in independent wireless access points and not necessarily attaching to the central VLAN.”
  – Indiana University: “We’ve tried hard to establish standards and, for the most part, the departments have welcomed them and followed them. But it is very much the case that, to date, it has been physically possible for departments to install ‘renegade’ wireless infrastructure. We’re trying to get that under control (though we don’t have much of a problem) through our new policies.”
Factors in Decision to Implement Wireless

- Better access to the network is the key factor in driving wireless network implementations
- Operational issues and cost savings are of lesser importance

- Student anytime access: 51%
- Growth ability: 43%
- Classroom access: 43%
- Faculty anytime access: 41%
- Solve specific problem/app.: 38%
- Leading edge perception: 35%
- Commuter student access: 30%
- Easier move/add/change: 24%
- Savings over installing wired: 21%
- Competitive pressures: 21%
- Operating cost savings/wired: 11%

% of respondents rating factor 8-10 importance (scale of 1-10)
**Wireless is Meeting Expectations**

- Wireless communications has exceeded or met the expectations of nearly 90% of the respondents who have implemented it.
- But benchmarking a challenge, especially since wireless often viewed as supplemental rather than core.

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**Chart:**

- Exceeded expectations: 14%
- Met expectations: 74%
- Fell short of expectations: 7%
- Don't know / no answer: 5%

_N=299_
Success Measurement

- Most institutions track their wireless network success qualitatively using feedback
  - Florida State University: “Qualitatively. That is consistent with the campus culture”
  - Oberlin College: “Qualitatively, the folks that use it like it.”
  - Rockland Community College: “Qualitatively in terms of improved pedagogy.”
  - Middlebury College: “Qualitatively since in initial experimental deployment for single purpose.”
  - Maricopa Community Colleges: “The main issue is whether the network meets the faculties' needs.”

- Some use a combination of both qualitative and quantitative measurements
  - Duke University: “User experience is very important as well as number of total APs and registered users.”
  - University of Wisconsin - Madison: "The number of users and the number of complaints or praise.”
  - Dartmouth College: “Qualitatively, anecdotally, no formal plan in place. Some work done of monitoring use at AP's. Students and professors in the Computing Sciences department are studying wireless usage patterns.”
  - University of California - San Diego: “Success is measured based on user feedback and on growth of usage.”
  - University of California - Berkeley: “Quantitatively by the number of access points deployed (and requested) and the number of users of them. Qualitatively by feedback via the campuswide Task Force.”

- A few are quantitatively focused
  - College of Mount St Joseph: “Qualitatively, primarily. We do student surveys to find dead spots and satisfaction. However, by using the wireless network administration tools, we get quantitative readouts of performance, which helps us spot problem areas.”
  - Harvey Mudd College: “The number of happy users is the best gage. However, since we require registration for some wireless access, we also can watch the increase in total number of users. We also monitor traffic and watch its increase.”
  - University of Toronto: “Usage, reliability, security.”
Wireless Benefits

• Most institutions cited wireless’s convenience as a benefit
  – Harvey Mudd College: “Convenience is the biggest benefit. Sometimes the issue of convenience determines whether someone will try to incorporate technology into their teaching or not. Faculty being able to use their computer, configured how they want it, in a classroom is very appealing. Students being able to access the web at any time from any where, without planning for it, is a big plus.”

• Higher productivity is another benefit
  – Dartmouth College: “Definitely productivity, lower cost, service, convenience, efficiency. We receive glowing reviews - it’s a robust technology and people use and like it.”
  – University of Pennsylvania: “Higher user satisfaction, presumed higher productivity.”

• Lower costs
  – College of Mount St Joseph: “Deployment costs are much lower. There are no wired ports or cables to be damaged.
  – Maricopa Community Colleges: “It saved me money. I can share a cartful of PCs across six labs instead of buying equipment each one.”

• Other
  – College of Mount St Joseph: “The main advantages though are related to the user. They don’t have to go looking for a network port. They just turn on, log in and go. Or they can leave their machine on and just roam from place to place, connected and logged in all the time. Two of the most interesting aspects of wireless computing, coupled with a universal student computing requirement, have been the new workplaces students create and the forms of collaboration that take place. Now students can plop down just about anywhere and do some quick homework, or several of them can gather around a single laptop and work on something together.
  – Middlebury College: “Convenience, flexibility, did not have to “wire” classroom space. In future, look to attractiveness for flexibility in using outdoor spaces for study & classes, particularly in summer academic programs.”
Conclusions/Implications

- The expansion of wireless and wired networks continues in parallel (inconvenience vs. disaster)
- Phased rollout, with installing, learning, and revising seems the way to go
- Wireless standards will continue to be a challenge, especially when it comes to security

“The wilderness masters the colonist”

Frederick Jackson Turner,
Essay on the American Frontier