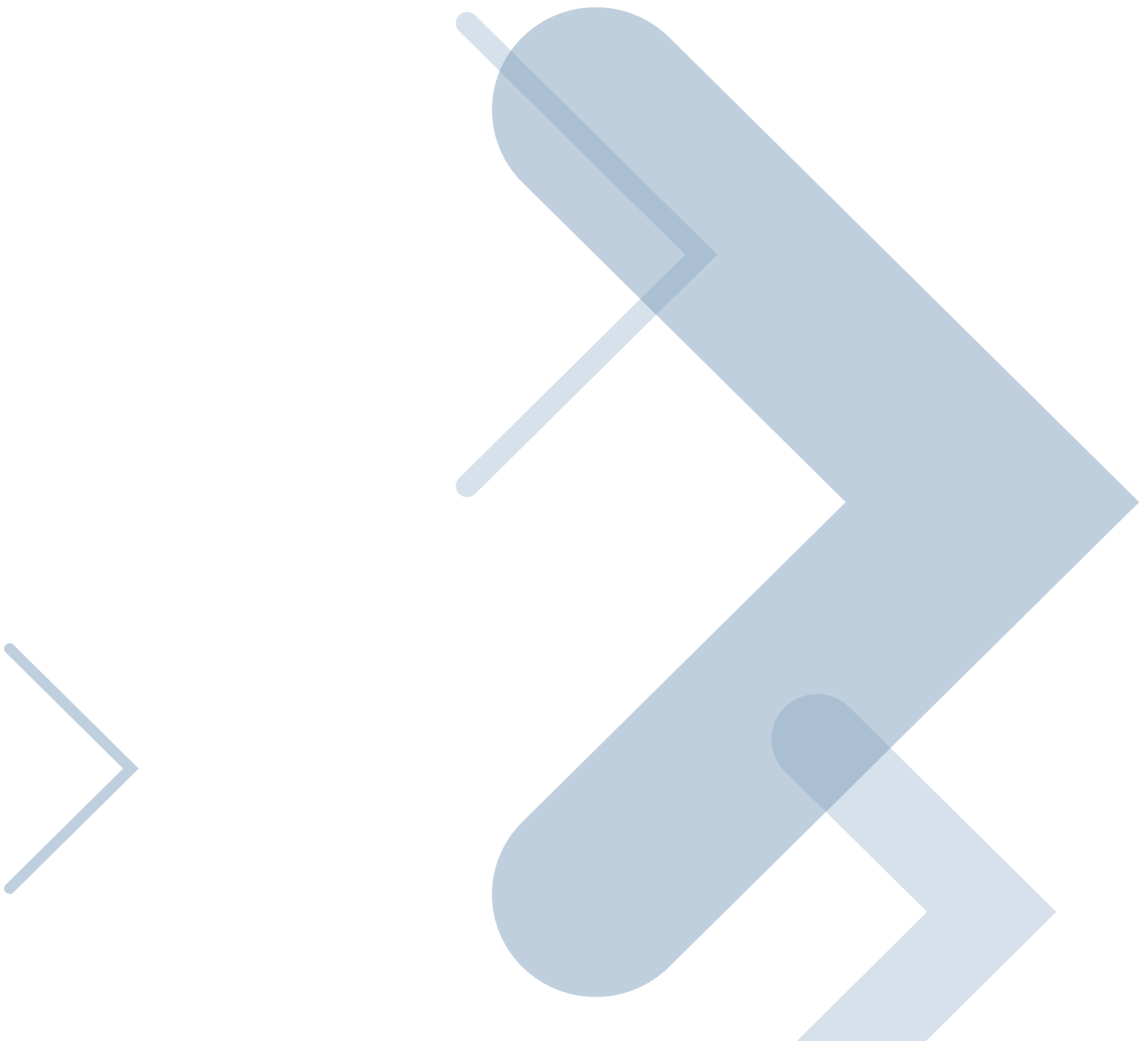


How Technology is Changing the Ways Students Learn and Teachers Teach

Wireless broadband technology solutions are crucial for keeping gaps in high-speed access from leading to gaps in student performance





It's all about increasing student performance.

The passion to help students learn is why most educators became educators in the first place. And in almost every case, the better a student performs, the better chance he or she has for success in school... and in life. Improving student performance is also crucial to a school's success. Because today, how students perform is how teachers and schools are evaluated. In K-12 environments, it's how they perform on standardized tests. For higher education institutions, it's about how their graduates perform in the world.

The burgeoning revolution in learning technology is fast becoming a major factor in improving student performance. In this paper, Motorola examines how the Internet and new online learning resources are revolutionizing the learning experience for students from K-12 to universities and graduate schools. The article also discusses the other equally important aspect of the technology revolution: making sure all students have access to these crucial new online learning resources.

E-Learning Trends

Imagine being a teacher on the frontier. You taught in a one-room schoolhouse and you taught students at ages that might range from first grade all the way up to high school. Sounds like a nightmare, but when you stop to think about it, don't today's teachers face similar challenges? Although students in a class may all be about the same age, they are anything but the same in their levels of interest and achievement. When you teach to the level of the less accomplished class members, the more accomplished students get disinterested and bored. And vice versa. Now, in the midst of this long-standing dilemma, comes the education technology revolution. And as it grows, it has the potential to be the catalyst for major changes in the way students learn and teachers teach.

The Personalization of Education

"The problem with improving student performance in today's educational system is that there's a lack of personalization," says Tom Greaves of The Greaves Group, a well-known education technology consultant. "The message isn't ideal for any of the students; it's either over their heads or under their heads." That's beginning to change. Today's advances in educational technology are transforming how students get information by making the educational experience more personal.

Not so long ago, a teacher might have instructed a fourth-grade class on mammals with a textbook and perhaps a short video that presented a broad overview of the material. But when students have access to the Internet — whether in the classroom, at home or, hopefully both — they can obtain much more information, not to mention much more interesting information. Instead of learning a little about a few

mammals, they can learn a lot about every mammal on the planet from aye-ayes to wombats. Students can work at their own pace and at their own level of interest. The deeper a student can get into a subject, the more involved, more intrigued and more motivated they're likely to be, and as a consequence, the more their performance is likely to improve.

The Evolving Role of the Teacher

So are teachers destined to become obsolete? Hardly, says Greaves. "As a matter of fact, teachers are more valuable than they've ever been, but their role is changing. They become less the deliverer of educational information and more of a teacher, working with students one-on-one and in small groups, and able to go much deeper into the material." This prediction is supported by other industry sources. In their book, *Disrupting Class*, authors Clayton Christensen, Michael Horn and Curtis Johnson predict that by 2019, 50 percent of all high school courses will be delivered online.

The New Learning Technologies

How do teachers feel about this shift? Most like it. According to the February 2010 issue of *Tech & Learning* magazine, if teachers could wish for one thing, it would be more money for technology. Teachers are also practicing what they preach. For example, the magazine also notes the increasing usage of technology by K-12 educators, with 76 percent saying they use digital media (up from 69 percent in 2008) and 80 percent of those describing themselves as frequent or regular users. In addition, 72 percent stream or download content from the Internet. Clearly the education technology revolution is no longer coming. It's here.

K-12 EDUCATORS
USE OF TECHNOLOGY
IN THE CLASSROOM

76%
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Keller Independent School District (ISD), one of the fastest-growing school districts in the state of Texas, comprises 36 schools with some 30,000 K-12 students. To support its e-learning activities, including a 1:1 computing initiative that will eventually provide laptop computers for every student, the district partnered with Motorola and SAFARI Montage. The district chose SAFARI Montage video-on-demand to deliver digital e-learning content to dense classroom environments. And after testing several WLAN alternatives, Keller ISD deployed Motorola's 802.11n wireless LAN infrastructure because of its superior ability to support this high-bandwidth application in such dense environments. Together the Motorola wireless network and SAFARI Montage system are enabling Keller ISD to deliver multiple multi-cast and uni-cast video streams simultaneously to multiple clients in classrooms across the district.

How are educators using the new educational technologies to help improve student performance? They use it in a number of ways, including:

- **Content and Research.** Access to the Internet provides students with access to a world of multi-media educational content that's a quantum leap from the textbook. From streaming video to online courses and lectures, a motivated student can and will find out just about everything he or she wants to know. When Tom Greaves recently asked a sixth-grader about the difference computers and the Internet are making in her school work, she told him, "Before computers, I couldn't get the answer to any question. After, I can get answers to every question."
- **Administration.** A rapidly growing number of schools at every level are using today's powerful, multi-faceted learning management systems, such as Blackboard, Moodle and RM Learning Platform. These software applications include components for a wide range of crucial functionalities, including customized online learning experiences, automated record keeping, automated tracking of student performance, communications, security, training and more.
- **Assessment.** Online assessment and testing are beginning to make inroads on traditional testing methods, with interactive computer-based tests offering more effective, more efficient alternatives to the old paper-and-pencil, monitor-in-the-classroom model. Grading is faster and easier and students can take tests virtually anywhere. In addition to today's standard multiple-choice tests, new initiatives are underway to develop interactive tests in which students are required to generate their own content and material rather than simply choose an answer.

- **Virtual Classes and Classrooms.** Distance learning initiatives have traditionally focused on providing virtual classrooms for rural and outlying areas where students may have difficulty traveling to and from school every day. Today the virtual classroom is expanding. Virtual classes are now being used virtually everywhere: from on campus to at home to wherever a student wants to use them. They're even being used in non-virtual classrooms to deliver a bold new world of content from a wide range of resources, such as school-created programs, downloadable lectures from the Internet, materials from sources such as iTunes U and TeacherTube and new Web 2.0 applications.

1:1 Computing

One indication of the growing importance of e-learning is the rapid rise of 1:1 computing, or the policy in which K-12 schools, school districts and universities provide each student and faculty member with a laptop computer, netbook or other personal computing device. According to *America's Digital Schools 2008*, the use of 1:1 computing strategies is rising dramatically, especially in the K-12 environment. Currently 27 percent of school districts have 1:1 pilots of at least a full school grade. Another 22.5 percent plan to implement 1:1 in the next few years. Results have been increasing, too. *America's Digital Schools 2008* also notes the steadily rising number of districts using 1:1 computing models that are reporting moderate to significant academic improvement. This number rose from about 30 percent in 2006 to more than 78 percent in 2008. There seems no question that properly implemented technology solutions can yield excellent results in terms of performance.

Technology Trends

Of course, 1:1 computing, Web 2.0 access and online-based e-learning applications are only one part of the educational technology equation. Once you've put these exceptional new learning tools and resources in place, you must make sure every student can use them... not just in class but whenever and wherever they want to. In other words, e-learning systems must be able to function as an electronic textbook.

The Textbook, Pro and Con

Say what you will about the textbook, although it has many disadvantages, it also has one major advantage. No textbook can hope to compare to new e-learning resources in providing a wealth of information on any subject. No textbook is as interesting or as motivating as streaming video and lectures from the world's most renowned experts. Textbooks are not meant for collaboration and it's too easy for them to become obsolete too quickly. But the textbook does have one big plus. It can be used anywhere: in class, at home, at the library, in the dorm, in the coffee shop, in a car, even outdoors in the park. The question is, how can e-learning be made as usable as a textbook, because only then will the performance improvements promised by education technology be completely realized.

The Access Imperative

The overarching objective of educational technology is improvement of student performance. Unfortunately, in many school districts, e-learning systems cannot pass the "textbook test" in part because of the so-called "digital divide." To be as usable and as accessible as a textbook, educational technology must be available to all students in the classroom, on the school's campus and virtually everywhere else in the community: at home, on the bus, in a restaurant, on the street, virtually anywhere and everywhere.

For students living in areas or under circumstances that don't allow for Internet connectivity, this is a huge problem. Lack of access can lead to certain students being unable to use resources that others are using, even if they have their own computer or netbook. That can lead to performance gaps, and that is unacceptable.

The Bandwidth Crisis

Before we discuss how schools are planning to overcome these gaps in access, let's bring up a related issue: the need for *broadband* access. The reality is, the rich multi-media content of most educational technology solutions is exceptionally bandwidth intensive. In other words, most e-learning solutions need a high-speed broadband connection to make them truly viable. Once again, students who lack sufficient bandwidth to make full use of online resources are more likely to suffer from performance gaps.

"Making sure students have sufficient bandwidth is a significant driver for the current administration's National Broadband Initiative," says Greaves. "Without enough bandwidth, students will have no high-speed Internet functionality, no fast downloads, no fast searches, no streaming video, fewer opportunities for online collaboration.

The question is: How will educational institutions be able to deliver the kind of bandwidth that will improve student performance? And how will they be able to afford it?

Wireless Broadband

Most educational institutions have wired network backbones that make use of T1 connections or fiber. While they continue to serve schools well, there are two issues. The first is that typical T1 connections, especially as used in rural areas, deliver throughput of about 1.54 Mbps, far lower than necessary to support bandwidth intensive education technology solutions. The second is the cost of expanding a school's fiber network is exceptionally high, not just in monthly rental costs, but also in the digging and trenching usually necessary for wired network expansion. The most viable answer for many schools is proving to be wireless broadband networks.

As noted in *America's Digital Schools 2008*, "The rapid growth of [wireless broadband] solutions has allowed districts to substantially expand data rates at a lower cost per megabit than [wired] solutions." The next question is which wireless technology is best for the school's unique requirements, including both high-speed fixed and mobile connectivity.

A Range of Wireless Options

In today's marketplace, educational institutions of all sizes have a wide range of wireless technology choices that enable them to design and build a network that can serve all three of their targeted environments.

TEENAGERS USE OF TECHNOLOGY

60%
HAVE DESKTOP/LAPTOP

97%
PLAY VIDEO OR
COMPUTER GAMES

93%
USE THE INTERNET

Source: Pew Internet & American Life Project





Located in Marquette, in Michigan's Upper Peninsula, Northern Michigan University is a comprehensive, masters-level institution serving almost 10,000 students. The school began a 1:1 computing program in the year 2000, providing students with laptop computers and access to its WiFi campus network. As the number of students living off campus grew to about 6,000, the school realized it needed to extend wireless coverage to serve not only its students on campus, but also those living off-campus in the city of Marquette itself. Because its WiFi network was incapable of supporting high-speed access in the area's hilly, wooded terrain, the school chose to deploy a Motorola WiMAX system for its ability to provide reliable broadband over a wide coverage area. Today, the network is serving virtually all of NMU's students, both on and off campus, as well as more than 17,000 other users in the city of Marquette and its surrounding area.

By providing this high-speed connectivity, NMU is playing an important role not only in helping students improve performance, but also in helping the entire region develop critical new economic growth.



In the Classroom

The old classroom model of teachers teaching mainly by imparting knowledge to the entire class is fast disappearing. Today's classroom is a more interactive environment with multi-media content — such as new e-learning applications and the Internet — enabling teachers to provide more personalized learning experiences to individual students working on individual laptop computers and other electronic devices. Making it all possible are new Wireless Local Access Networks (WLANs) that are a quantum leap in bandwidth and interactivity from WLANs of even a few years ago, working in tandem with the school's wired or wireless backbone network to make online access faster and easier.

Today's WLANs outperform older networks in a number of ways:

- **Significantly higher bandwidth.** Enabled by the newly ratified 802.11n standard, today's WLANs are capable of delivering significantly higher throughput required for today's bandwidth-intensive applications. Where older networks normally delivered throughputs of 15 to 20 Mbps on a good day, 802.11n networks can regularly deliver up to 300 Mbps, enabling students to take maximum advantage of bandwidth-hungry applications such as streaming video, interactive collaboration and high-resolution downloads. Wireless broadband networks based on the 802.11n standard also provide the capacity to serve a large number of individual users in high-density locations such as classrooms.
- **Faster routing of information.** The more advanced WLANs available today also ensure faster, more efficient routing of learning content via more intelligent adaptive architecture. These new networks eliminate the bottlenecks that can hold up transmission of content by placing more intelligence in the access points, keeping data

from backing up either at the access point or controller level. Gone are too-long waits and too-frustrated students and teachers.

- **Support for other applications.** New WLAN solutions are also more easily scalable when expansion is needed, and they support complete in-building connectivity and a wide range of new and emerging educational and operational applications, such as Voice over WLAN (VoWLAN) VoIP, video conferencing and surveillance.



Across Campus

Today's students are more often than not what are called "digital natives," i.e. individuals who have grown up with digital technology and take ubiquitous high-speed connectivity for granted. Basically, they want to be able to use technology the same ways — and the same places — they might use a textbook. They want connectivity not just in the classroom, but everywhere on campus: indoors in the cafeteria, the library and study halls, and also outdoors in common areas, in sports facilities, on the street, in parking lots, throughout the campus. There's no doubt that today's K-12 and higher education institutions are under increasing mandates to provide the kind of cost-effective blanket broadband coverage for the entire campus that wireless networks can deliver.

Outdoor campus network considerations include:

- **Seamless indoor-outdoor coverage.** It's vital that these campus-wide networks include coverage that can follow a user inside and out, eliminating the dropping of connections while a user is entering or leaving a building. Lack of seamless coverage that allows roaming between access points not only increases frustration, it also decreases productivity.

- **Powerful access points.** Today's 802.11n-based WLANs are exceptionally cost-effective. Using more intelligent outdoor access points that are also more powerful and efficient, the networks enable full campus coverage with very few APs — in many cases only one. In addition, the APs can mesh directly to the network, eliminating the need for — and expense of — backhaul technology.
- **More aesthetic deployment.** For many traditional colleges and universities, their beautifully classic campus environments are a major selling point. As a result, when deploying network telecommunications equipment, IT departments must not only be concerned with connectivity, they must also be concerned with aesthetics. Because they generally need fewer pieces of equipment than previous networks, effective 802.11n wireless broadband solutions require fewer access points and incorporate integrated panel antennas making them less obtrusive in the campus environment.



In the Community

Many school districts, colleges and universities are situated in communities and areas where broadband Internet access is either unavailable or unaffordable for the significant number of students who live off campus. These institutions are faced with a separate challenge. To make sure of a level playing field in terms of Internet access for all students, these schools may consider deployment of a community-wide wireless broadband network.

Before a decision is made to explore the community option, there are a number of questions that should be asked and answered:

- What specific objectives must the network accomplish? For example, do you need to ensure coverage to an entire community in an outlying or rural environment, or do you need to cover a specific area in a city or other municipality?
- What is the use case? For example, who are the students you propose to cover and where do they live? Is your target area an underserved urban environment where students cannot receive or afford high-speed access? Or is it a few square blocks contiguous to the campus that contains a majority of off-campus housing?
- What types of buildings and terrain must be served? In planning any wireless network, land topography and building heights and construction materials will help determine how much interference is likely to be present, and how much throughput will be necessary to provide broadband service. Are there tall high-rise buildings that create a canyon-like environment? What materials, such as concrete, wood or steel, are most structures made of? Are there hills, dense stands of trees, rivers or lakes the signals must traverse?

Wireless Technology Options

When these and other questions have been answered, schools have a number of technology options that should also be examined. These include:

- **WiMAX.** Many schools possess licenses in the 2.5 GHz frequency band. WiMAX networks are an ideal technology for community networks, supporting cost-effective high-bandwidth coverage, high-speed mobility and powerful signals that increase reliability and reduce the effects of interference. WiMAX is especially valuable in dense urban environments as well as in smaller rural and exurban environments where a small number of WiMAX sites located on the tops of buildings can serve a large number of users spread across a broad area effectively and cost-efficiently.
- **PTP and PMP.** Point-to-point and point-to-multipoint wireless networks using either licensed or unlicensed spectrum are also excellent network technology alternatives. In environments where students tend to live in within a few miles of the campus, PMP networks with service modules located in buildings and homes are an excellent, cost-efficient alternative. PTP networks are also viable for providing high-bandwidth backhaul to off-campus facilities or to outdoor WLANs in distant neighborhoods.
- **Outdoor WLAN Extension.** In many school districts, especially in densely populated urban areas, the preponderance of students live within two or three blocks of the school. Similarly, in many college and university environments, off-campus housing is contained mainly in a radius of just a few blocks. In these types of situations, intelligent outdoor WLAN access points can be located in the neighborhood and connect back to the school's network using self-meshing technology.

Community Network Funding Options

Community networks are a large-scale undertaking to be sure, but there are a number of scenarios in which deployment of this kind of network is both needed and affordable. These include institutions funding their own networks, often leveraging their ownership of 2.5 GHz WiMAX spectrum, which not coincidentally, face a May, 2011 deadline to provide plans for the spectrum for which they hold licenses. Other scenarios include a growing number of public-private partnerships, with school districts and universities often partnering either with community government or with a local service providers to fund and deploy multi-function networks. These networks provide broadband connectivity for both the institution's students and municipal, residential and commercial usage.

Next Steps

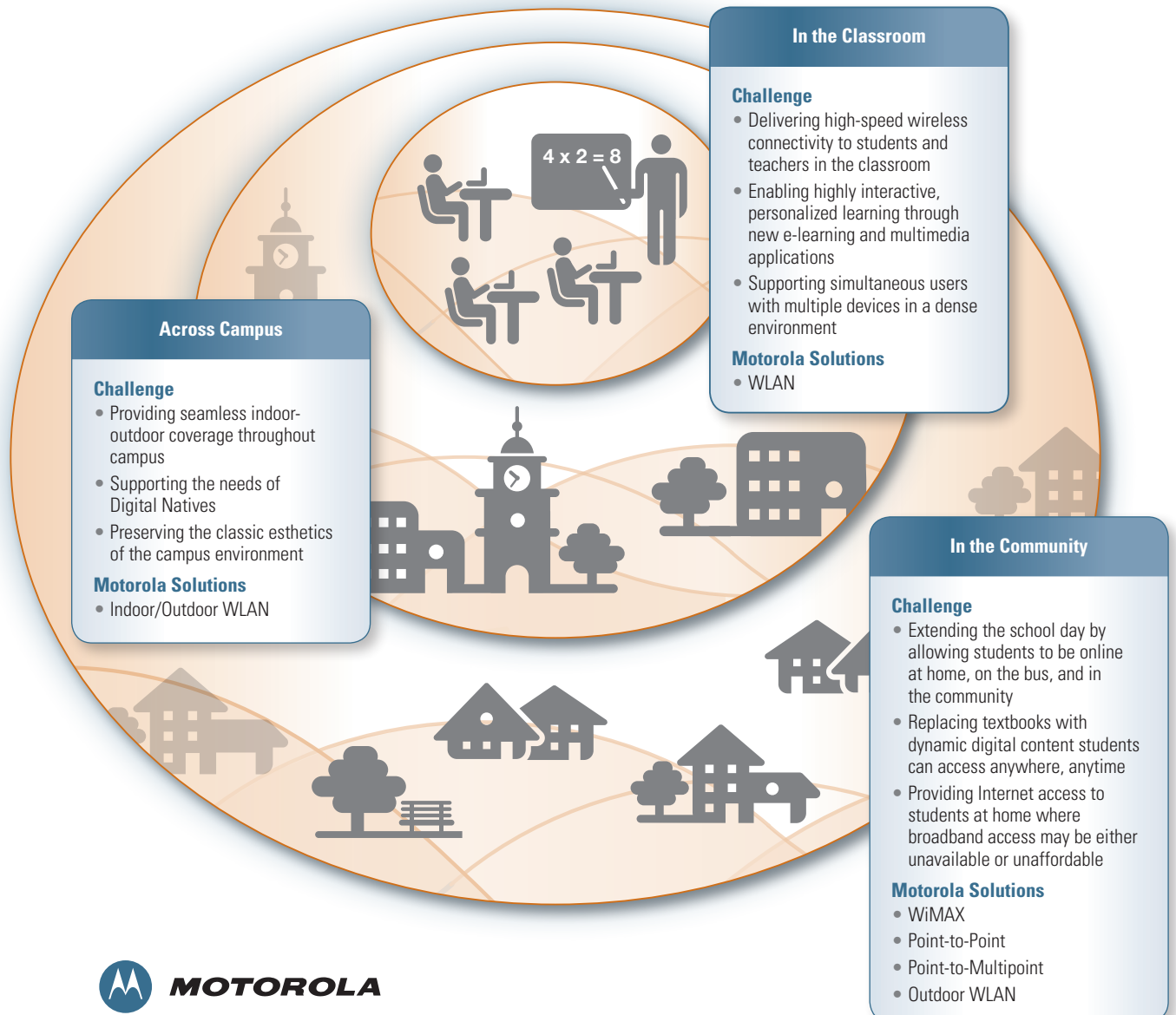
Schools in the initial stages of considering deployment of a wireless broadband network to support their growing e-learning initiatives can find themselves in uncharted territory. There will be a great many questions to be asked and answered. Where will schools find the answers and the technology solutions they need? As a pioneer and leader in wireless technology and with a long history of successfully supporting educational environments with communications technology, Motorola has the answers.

With our industry-leading portfolio of wireless broadband network solutions — including indoor and outdoor WLAN, PTP, PMP, mesh and WiMAX technologies — Motorola is one of the few technology partners that can support connectivity in each of the institution's targeted areas: in the classroom, across

the campus and in the community. In addition, Motorola provides AirDefense, one of the world's most powerful security solutions, and the integrated One Point Wireless Suite with multi-vendor management and troubleshooting capabilities.

Personalization and Performance

Individual schools, K-12 school districts and higher education institutions alike are racing to design and deploy wireless broadband networks that can cost-effectively deliver the bandwidth to support the new e-learning technologies and applications of the present and the future. By providing more compelling, more motivating, more personalized educational environments designed to improve student performance, e-learning applications and high-speed wireless network solutions are poised to revolutionize education. It's crucial that no school — and no student — be left behind.



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