Moving From "Dumb" To "Smart" Classrooms: Technology Options And Implementation Issues

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ABSTRACT

What are "Smart Classrooms" and why do we need them? What technology components are necessary for a smart classroom, and what are the implementation challenges?

INTRODUCTION

This paper begins by justifying the need for more interactive classrooms that enhance today's students' learning styles. Information reception, processing, and retention have changed with the advent of the digital millennial learner, and teachers and learning spaces need to adapt to these new learning paradigms.

Most of today's traditional college-aged students (17-23) can be classified as digital millennial learners and are typically part of the Net Generation (NetGen), born during or after 1982. The NetGen student prefers to learn at their own pace. The like and are comfortable with an online environment for testing, lectures, and assignments. They are informal learners, preferring "any time, any place" learning to a traditional classroom. Class time is most effective for these students when it involves interaction, demonstration, and social networking. NetGen students are visual and kinesthetic learners who prefer to experience the world through multimedia and not print. This preference is often problematic for faculty who prefer to learn by reading and listening to a lecture. It is this dramatic difference in learning preference that can create a disconnect between student and teacher.

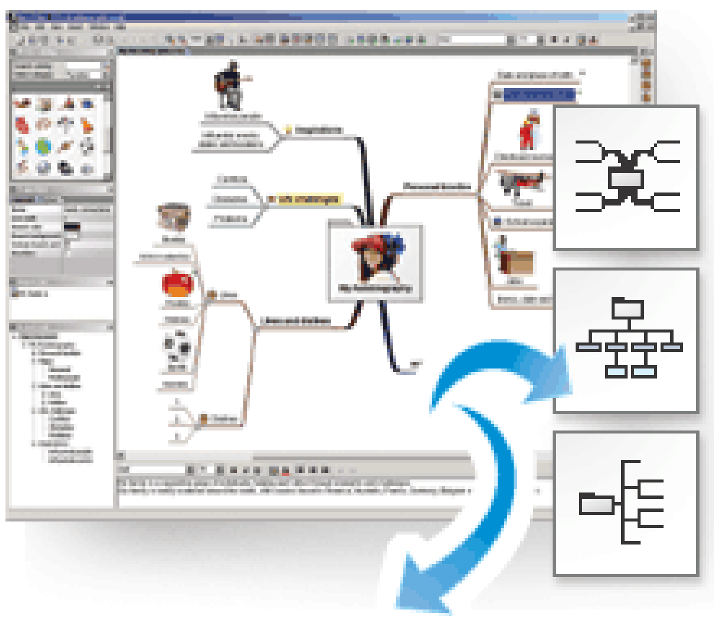
To engage the NetGen learner, a course must incorporate multimedia as well as kinesthetic experiences. Students like simulations and role playing scenarios as they prefer to experience things from a realistic, practical standpoint. That is part of the reason they rarely listen to a lecture—they need to go out and experience it for themselves—sometimes despite the consequences. To cater to this learning style and preference, real-world projects and tasks are excellent ways for them to experience the real world and focus on the WIIFM (*What's In It For Me*) mindset.

TOOLS AND TECHNOLOGIES

There are many tools and technologies available for creating interesting, relevant learning opportunities. The easiest and most common is to use PowerPoint to incorporate some multimedia into a lecture. It is imperative that professors not read from the slides directly as the students perceive this in a negative way. Instead, use PowerPoint as a basis to begin an interactive discussion in which students can share their views and experiences with each other. Online Learning Management Systems (LMS) are an excellent way to do this as discussions can begin online before the class session does and/or continue long after the class is over. Remember, NetGen students learn by building concept maps (see figure) and they may not "get it" in the classroom, but rather later on after they have reflected on it.

So how can an entire class be interactive? One method involves engaging the students, and often. Most NetGen students have a 7-minute attention span and technologies like Turning Point's Audience Response System™ (AKA "clickers") can be used to assess their comprehension, interests, and opinions. If they feel as if you care, they are more likely to be engaged and learn. They also like playing with "digital toys" like the clickers and other technology devices. Varying the method of presentation is also important. Intertwined in the lecture should be video and/or audio clips that students can listen to either in class or afterward—remember they learn visually and like multimedia.

Some software tools that are available for creating multimedia lectures and presentations include MatchWare's Mediator™ which allows website design without any knowledge of HTML or programming. Students take to this very quickly and are often able to create applications without any formal training—they just click and learn on their own by doing. The software is feature rich, easy to use and relatively inexpensive, with site licenses for entire learning communities at home or school. Another MatchWare product is ScreenCorder™ which is excellent for recording voice-overs on your PowerPoint slides. Students like the ability to listen to the lecture when it is most convenient for them and when they need to process the material again. This works well in both on-line and traditional classroom learning environments as students have access to the material and can listen to it at their convenience. The final MatchWare product is called OpenMind™ and it allows concept maps (see figure) to be built either from scratch by students for their own use or by instructors for their students. In fact, a traditional outline format can be created and then converted to a concept map. The product is also excellent for websites, presentations and general note taking by students. It is also very easy to use and students can pick this up with very rudimentary training. Remember, this method of learning is what they prefer best—"show me and then get out of my way!"



Source: OpenMind™ MindMap (http://www.MatchWare.com)

LEARNER EXPECTATIONS

Technology aside, students must be engaged using the three Hs: Head, Heart and Hands. Most NetGen students do not question the instructor's knowledge on the subject—to the contrary—they expect the instructor to be an expert in the topic and be able to pass that knowledge on to them. NetGen students also need to feel that the instructor has a heart and cares for the students. This includes responsiveness and empathy for them and their problems. It also includes an enthusiasm for the topic and teaching in general. Finally, good teaching skills are necessary. Use of the "hands" to convey ideas at the right level, in a clear and systematic manner which stimulates their interest and learning is vital.

The learning environment of the physical classroom in which students learn is also important. As previously mentioned, they are "any time, any place" learners and prefer informal learning spaces to more formalized ones. To this extent, they embrace and even demand a wireless environment where they can connect to the Internet and share information in the form of email, instant messaging, blogs (web logs) and the ability to just search for information on the web. The next section will explore some possibilities for creating a physical learning space that accommodates the digital millennial learner.

SMART CLASSROOM TECHNOLOGY OPTIONS

What is a smart classroom? If there are differences between the degrees integrated instructional technology, what are those differences? How expensive is it to build up existing instructional space to take advantage to the potential learning environment that such instructional technology makes available? Last, what other aspects to the instructional space are important when determining the level of investment appropriate for your specific instructional needs? Understanding these topics will help you make intelligent decisions about "how much," "when," and "exactly how" as it applies to the particular needs of your institution.

The discussion in this section of the paper will assume an instructional space that already possesses a dry-erase/chalk board, tables/seats for the students, and appropriate lighting. In terms of the integration of high-tech instructional technology within a teaching space, there are four basic levels of classrooms:

- Level 1 – the A/V Classroom
- Level 2 – the Technology-Enabled Classroom
- Level 3 – the Technology-Enhanced Classroom
- Level 4 – the Smart Classroom

Beyond the basic groups are a set of four additional distinctions which further delineate the potential of the instructional technology integrated into the teaching space:

- Can the space be remotely administered or not
- Is the space information enabled (with access to the intra-/internet from the teaching podium), information enhanced (with said access delivered to both the podium and all students), or is it information isolated
- Is the classroom RF shielded (or 'quiet'), preventing students from using wireless devices such as cellular phones or wireless computers
- Are high-value instructional technology devices secured using appropriate anti-theft technologies or left unsecured

One of the key distinguishing differences between the four levels of high-tech classroom relates to the degree of control and integration found between the different learning environment elements. With greater integration comes the potential for greater remote administrative control. This particular classroom distinction will be made in detail in the breakdown below.

While any of the four classroom types can setup for wired/wireless access to the intra-/internet, the issue of whether or not a room should be information enabled, enhanced, or isolated is outside of the scope of this paper. This topic must be considered, though, when deciding on the specific kind of high-tech classroom to adopt as the appropriateness of such access may vary across disciplines and/or the student capacity of the particular space.

The issue of whether or not to make an instructional space 'quiet' through the use of RF scramblers (as some movie theaters are choosing to do to prevent cell phone use during their feature presentations) relates to the questions of how to minimize both (a) information distraction (students chatting or browsing instead of participating), and, (b) the potential for high-tech cheating during graded assessment (through the use of camera phones or instant messaging). Though the decision of whether or not to make a space ‘quiet’ can be applied to any of the groups of classroom outlined below, the question of whether or not to employ such technology is outside this paper’s scope.

Though this may seem insignificant in the big picture, one of the most important issues with the use of technology in the classroom relates to whether or not the faculty member has comfort with the technology, adequate training in its use, and a reasonable expectation that the equipment will both be operating properly and be in place when the faculty member goes to employ it. Failure in any of these areas will result in an investment in instructional technology that faculty choose not to employ. Securing instructional technology can be both expensive and inconvenient in application; even so, this issue is important when considering when determining the specific type of high tech classroom which would be most appropriate for your institution. Specific options for securing high-tech instructional technology can be found in Skipton & Matulich (2005).

Level One: The AV Classroom

The A/V classroom is populated with non-integrated instructional technologies such as an overhead projector with manual mechanical projection screen and a television (either attached to the wall or a cart) with VCR and/or DVD player. Potentially, such a space may be served by a shared computer projector which is either wheeled into the room on a cart or set up on a table before class.

In an A/V classroom, none of the systems of instructional technology work together. The systems may not be remotely administered (if there is a problem with a setting or cabling with the TV and the DVD player, an actual person/tech has to come to the teaching space to diagnose the problem or adjust the setting). External amplified speakers for the television or an introduced laptop computer are separate, repetitive investments. Climate and lighting settings are set manually and are not designed to complement the particular type of A/V equipment which may be set into use.

Cost estimates for retrofitting existing teaching space to an A/V classroom range from $500 to $1,000 (without a shared computer projector) and from $2,000 to $3,000 (with a shared computer projector on a wheeled cart).

Two: The Technology-Enabled Classroom

The technology-enabled classroom is characterized by a first degree of instructional technology integration. The locus for control is situated within an appropriately scaled, permanently affixed computer projector. Such a classroom is populated with a DVD/VHS combination player, a ‘pig-tail’ cable for attaching an instructor’s laptop computer, a manual mechanical viewing screen, a mounted control interface, and permanently mounted speakers.

At the heart of the technology-enabled classroom is a computer projector with multiple A/V inputs. The DVD/VHS player and a laptop pig-tail each send their video feed (along individual sets of cables) to the computer projector which acts as an electronic switch. The projector is capable of receiving remote commands for power, the choice of video source, and volume level from a mounted control device (something like a Pixie Control (SP Control Systems) which is essentially a hard-mounted remote control). The projector also pushes out a variable audio feed which is then amplified by an external amplifier before then being sent to permanently-mounted speakers. Each of the A/V systems in a technology-enabled classroom shares one projection and audio system, which allows for that aspect of the technology to be fine-tuned (for picture and audio access from every student position). Climate and lighting settings are set manually and are not designed to complement the particular type of A/V equipment which may be set into use.

As to the degree of remote administration possible, the addition of a network interface device like an Extron IP Link makes possible many different powerful functions. A remote administrator can diagnose and often fix problems remotely (power on/off a projector, change sources, detect a bulb or connection failure, or even change the projection settings to correct for picture quality). Using the monitoring feature of the software, the administrator can use this same network interface device to detect when/if the projector (a high-value instructional technology asset) is removed from its station; unauthorized removal of the projector can be set to trigger notification systems for security or technology support personnel.

Cost estimates for retrofitting existing teaching space to a technology-enabled classroom range from $3,000 to $6,000 (without a network interface device) and from $3,500 to $6,500 (with this option).

Level Three: The Technology-Enhanced Classroom

The technology-enhanced classroom is characterized by an enhanced degree of instructional technology integration. The locus for control is situated within an electronic switch, bolted to a steel rail (standard A/V rack), affixed to a technology kiosk in the classroom. Such a classroom is typically populated with a DVD/VHS combination player, a ‘pig-tail’ cable for attaching an instructor’s laptop computer, an auxiliary A/V feed (a left & right audio and video input for other portable A/V equipment to use), a manual mechanical viewing screen, a permanently mounted computer projector, a mounted control interface for the projector (power on/off), and permanently mounted speakers. Technology-enhanced classrooms often also include a document camera (such as an ELMO) and/or a permanent PC (station).

At the center of the technology-enhanced classroom is a dedicated electronic switch (like an Extron System 5 IP) with any number of inputs and multiple types (RGP, DVI, VGA, etc.) of shared, leveled, video cabling systems to the computer projector. Each A/V device in the room feeds video and audio into the dedicated electronic switch. The switch is manually controlled by the instructor through the use of buttons/switches typically built into its face. The display device (the computer projector) is capable of receiving power on/off commands from a mounted control device of the same sort used in the technology-enabled classroom. The electronic switch acts as a powered amplifier for all audio fed into it. The audio is sent from the switch directly to a system of mounted, amplified speakers. Each of the A/V components in a technology-enabled classroom shares one projection and audio system, which allows for that aspect of the technology to be fine-tuned (for picture and audio access from every student position). As with the Level 1 and 2 teaching spaces, climate and lighting settings are set manually and are not designed to complement the particular type of A/V equipment which may be set into use.

There are two portals for remote administration in a technology-enhanced classroom. The primary is through the electronic switch. Any function running through this switch can be controlled or monitored remotely. The remote administrator can change inputs, check for source feed, or even change the volume of the sound system in the room. The addition of a network interface device like an Extron IP Link, allows for remote administration of projector-specific functions, trouble shooting, fine-tuning, and security monitoring.

Cost estimates for retrofitting existing teaching space to a Level 3 technology-enhanced classroom range from $5,500 to $8,000 (without a permanent PC station, document camera, and network interface device) and from $8,500 to $11,500 (with these options).

Level Four: The Smart Classroo

The smart classroom possesses the capacity for the full integration of both the broad range of instructional technology and the many other broader aspects of the general learning environment. The locus for control is a dedicated control device which integrates a system of non-integrated switches, application-specific amplifiers, and (potentially) environment-specific control interfaces. Such a classroom is typically populated with a DVD/VHS combination player, a ‘pig-tail’ cable for attaching an instructor’s laptop computer, an auxiliary A/V feed, a document camera, a permanent PC (station), a permanently mounted computer projector, a powered viewing screen, a programmable control interface, and multiple application specific, mounted speaker systems. Smart classrooms often also include a control linkage for different parts of the instructional environment such as lighting systems, access control/monitoring, and/or HVAC.

At the center of the Smart classroom is a dedicated control device (like a Crestron). This type of infrastructure is a natural extension of both the evolution of centralized control and simultaneous disintegration of the functional duties found as classrooms move from Level 1 to Level 2 and then to Level 3. The dedicated control device, along with all of its non-integrated switches, amplifiers, equalizers, and control interfaces (for environmental aspects of the classroom) is typically housed in either a separate room or a proximal, locked closet. Each of these parts of the instructional technology is a limited-interface device (LIF) with physical access available only to technical associates and/or remote access made by network administrators. The non-limited-interface devices (NLIF), located in a media podium in the classroom, include the DVD/VCR player, document camera, auxiliary port, wireless/podium microphone, and a graphical user interface. NLIF media devices located in the classroom send signals to the LIF control device. The control device then parses out the video or audio signals to the appropriate switches, amplifiers, or equalizers in the rack mounted around it. As with the dedicated electronic switch in the technology-enhanced classroom, most any type of video source (RGP, DVI, VGA, etc.) can be handled, processed, and delivered to the shared display adaptor (the computer projector) in the classroom.

Unlike the technology-enhanced classroom, the non-integrated system of devices in the smart classroom can handle different kinds of amplifiers and different types of dedicated equalizers to "sweeten" the sound in the teaching environment to take best advantage of the needs of the different kinds of audio it might be handling. Further, multiple systems of speakers can create "multi-zone audio" with, as an example, sound for DVDs/VHS coming from surround sound speakers placed in the appropriate positions around the room while spoken word audio (from the wireless/podium microphone) is pushed through a different set of speakers scattered around the room to make the lecture equally accessible for students in the front row as those in the back reaches of the balcony.

In the same vein as multiple systems of audio is the opportunity to use different systems of lights – or different patterns/levels of groups of lights – to create optimal lighting combinations for different instructional tasks (low light along the perimeter for "theater lighting" or the creation of dark areas around the projection screen when it is lowered). Finally, control interfaces for HVAC can permit the control device to run preset patterns of climate adjustments based on time of day, enrollment during a particular time period on particular days, or even allow for need-specific adjustments to climate settings to be made from the control interface at the podium in the classroom.

The nature of the control interface used in smart classrooms clearly outlines the most important distinction between the technology-enhanced and smart classrooms. The control interface, typically a touch panel screen which displays programmed pages of buttons, level slides, and feedback information, is *specifically designed* by the administrative staff to suit the particular needs and particular assets in place for this specific classroom. These pages are ultimately flexible and send information from the user in the classroom back to the control device in the media rack regarding specific "bundled needs." What is a bundled need? If you want to use the projector you press a button to that affect on the touch screen control device which sends a "screen down" command to the control device which then interprets that command "screen down" to mean "send appropriate signal to powered screen to motor-down" and "send appropriate signal to lighting environment interface which then signals the lighting control infrastructure to dim banks one and two to 40% full power, to turn off bank zero (around the screen), and to activate the strip lights along the walkways" while at the same time it sends a signal to the projector to "power on." The control device is capable of controlling any device attached to or "integrated through" it. The macros of bundled commands for any particular need are written by the administrator and allow for full integration of the instructional technology due to the fully non-integrated or "prepackaged" nature of a truly smart classroom. The control device itself can be programmed to receive feedback on the status of equipment. It can be set up to show separate pages with sub-controls relevant only when specific choices have already been made. In short, the control device is as powerful as you want it and is able to be designed to send inputs to the control device with as much power as administrators would like to allow (as appropriate for that particular classroom's specific needs).

There are two portals for remote administration in a smart classroom. The primary is through the control device. A remote administrator can change see any feedback from any attached device and can send any signal or macro of signals to any attached device. The addition of a network interface device like an Extron IP Link, allows for remote administration of projector specific functions, troubleshooting, fine-tuning, and security monitoring (all discussed above). With regard to securing the high-value instructional technology assets in the room, feedback from and signals to electronic solenoids can be used to remotely lock or unlock doors (access control) into the teaching space; feedback from electronic contacts on the various doors/windows into the space can give live feedback (monitoring) regarding their closed/open status. Macros can be written to allow for behavior outside of a prescribed threshold to notify the appropriate administrators or authorities.

Cost estimates for retrofitting existing teaching space to a Level 4 Smart Classroom range from $15,000 to $20,000 (for a non-environmental space – without systems of speakers and without a control interface for lighting systems, security infrastructure, and / or HVAC) and from $30,000 to $40,00 (with many of these options).

IMPLEMENTATION ISSUES

A smart classroom is more than just the technology components in a room. Implementation is a key issue, and there are several issues that must be addressed. First is the challenge of installation. Second is training and incentive programs so faculty can learn to use the classrooms and adopt the technologies. Support systems also need to be in place after the classrooms are in use, and budgets should be prepared for replacement equipment as well.

Installation

One critical budgetary item that is often overlooked is the actual installation of equipment in a smart classroom. Cabling often needs to be run through walls, floors, and ceilings, which may necessitate serious construction changes. Plaster or brick walls, concrete floors, or other obstructions may prevent easy placement of cables. Other structural deficits may prevent heavy items such as projectors from being mounted on the ceilings. In some cases, there is no structural support at all for mounting and securing equipment, and structural components must be custom fabricated and added. Time also needs to be allotted for not only installation, but also testing, documentation, and training.

Another factor regarding implementation and installations is the timeframe of installations. Several approaches can be used. One approach is to equip different classrooms with different packages of equipment so that each room serves a different use or need. The advantage of this implementation method is the ability to try a variety of smart classroom configurations without investing huge budgets into a single classroom configuration. Disadvantages include difficulty in scheduling the appropriate classroom, and dozens of classroom configurations with no standardization. Some schools are going with a tiered approach that allows them to create a few designated types of rooms. Fordham University has three levels of smart classrooms: general purpose, multi-purpose, and high-end. The last option is to adopt a universal classroom and have every classroom be the same type of smart classroom. Although more expensive in the short term, in the long term costs are saved because of bulk purchases of replacement maintenance parts, support, training, and adoption.

Training and Incentives

Faculty members are busy people, and the thought of taking time out to attend training and then having to revise a course to meet technological changes is a daunting factor. Certainly training should always be available and easily accessible, but better attendance and adoption is reported when incentives are offered to attend training (Ozcan & Matulich 2004). Other incentives include the technology itself – an upgraded laptop, special software, personal remote controls, and so on. Course offloads or stipends to incentivize the time-consuming migration of course materials to high-technology and multimedia offerings are also successful.

SUCCESS AND FAILURE FACTORS

Fortunately, smart classrooms have been evolving for over a decade, and we can learn from the success and failure factors already experienced by other universities. Here is a checklist of items:

Support

There needs to be enough AV and IT specialists to support and maintain smart classrooms. The more intensive the classroom installation, the more support will be needed. The staff needs to be involved in planning, implementation, support, repair, and future upgrading. First responders also need to be available when classes are being taught, which may include evenings and weekends. At RIT, a first-response team tries to solve problems in under one minute and no less than five minutes, so classroom instruction can continue without much interruption.

Training Resources

An educational resource center, or some sort of formalized instructional technology training program must be implemented. Without continuous opportunities for faculty to adopt new technologies and appropriate training, smart classrooms will not be utilized appropriately (Brzycki & Dudt 2005). The best solution is a physical space with a lab, meeting room, and training area where instructors can receive support, collaborate with user groups, test equipment, and work on classroom materials development.

Switchover Time

Many campuses are short of formal learning spaces, and classrooms are booked from morning until night. Often, there is only a 10-minute "switchover" time between classes, which means one instructor has to shut down and reset all equipment, and the next instructor has to connect and set up for their class, all within a few minutes. A successful smart classroom must allow for quick and easy interchanges between instructors and classes.

Keeping Current

Faculty and staff should annually review the quality, currency, and usefulness of the smart room's software and hardware. Schools should set up an assessment system to determine what is working and what is not.

Know Your Audience

It is critically important that faculty are involved in smart classroom planning. One of the fundamental considerations when setting up a smart classroom is the clientele. Who will use the room? What do they need to enhance their teaching and learning interactions? What is the comfort level with really new technology? Needs assessment of instructors, students, and the room itself is a critical success factor in smart classroom planning.

Keep it Simple (and Secure)

In line with knowing the uses and users of the room, it is important not to overengineer the classroom. Buy the technology you need, and add in baby steps as the need arises. However, any classroom technology needs to be secure. Nothing disrupts classroom instruction so much as missing equipment that has been stolen or damaged (Skipton & Matulich 2005).

CONCLUSION

A smart classroom not only enhances today's students' learning styles, but a thoughtfully constructed one can also make life easier for the instructor. Caution has to be taken, however, that classrooms are not overengineered, or leading-edge technology can become bleeding-edge technology (Murphy 2002). An example would be New Mexico State's adoption of a system that would allow instructors to conduct classes both live in the traditional classroom and online in real time, with interaction among either type of student. The system proved so complicated and expensive to maintain that it was abandoned at a tremendous loss in less than two years. Smart classrooms need to add value, and not detract from the instructor or student teaching/learning experience. And even the best designed and installed smart classroom is useless if faculty members don't adopt the features. Training and support is critical for the success of smart classrooms and the eventual success of the students taught in those learning spaces.

There is one more caveat. American colleges and universities have invested millions of dollars in equipment and smart classrooms (Allit 2005), but these investments don't necessarily result in improved teaching. Technology does not replace good teaching skills, but proper use of technology can enhance teaching skills and improve the learning experience (Young 2005).

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