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Virginia Tech-Wake Forest University School of Biomedical Engineering & Sciences: Providing New Tools for a New Program

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Abstract

The Virginia Tech-Wake Forest University School of Biomedical Engineering & Sciences (SBES) was established in 2001 to provide graduate programs and enhance research collaboration between the universities.[1] This school enables students to earn M.S. and Ph.D. degrees in Biomedical Engineering, a joint M.D./Ph.D. through the Wake Forest University School of Medicine, and a joint D.V.M./Ph.D. through the Virginia-Maryland Regional College of Veterinary Medicine. Given that students may take face to face classes on either campus or classes via distance learning while residing on their home campus in either Blacksburg or Winston-Salem, new instructional technology solutions and infrastructure are required to support this initiative. A project team, consisting of members from Wake Forest and Virginia Tech, was established to develop this innovative learning environment. A key feature of this learning environment is the ability for the professor to easily interact with students using multiple types of instructional technologies. The use of these technologies is particularly important given the course content from the medical and engineering disciplines. This paper will address network infrastructure solutions and lessons learned from the development of this state-of-the-art distance learning environment.

Introduction

The concept for the SBES was initiated by several faculty from Virginia Tech and Wake Forest University School of Medicine in 1999 as part of a grassroots effort to increase collaborative research and educational initiatives in disciplines related to Biomedical Engineering. Once SBES was formally established, Elaine Scott, interim director of SBES (Virginia Tech professor of Mechanical Engineering) and Pete Santago, associate director of SBES (Wake Forest associate professor and chairman of the Department of Biomedical Engineering), outlined the detail goals for the delivery of instruction and the instructional technology tools to support the school. Their vision for the SBES learning environment included the ability to provide an

environment where students and faculty can easily interact with each other using state-of-the-art instructional tools and techniques. The primary challenge for this project was finding the appropriate technological infrastructure to bridge the geographical distance while working within the guidelines of both universities' administrative policies and procedures. The successful collaboration among the various technical and instructional groups from both universities was critical to implementing creative and stable instructional technology solutions.

Background

The brief overview of the SBES that follows will highlight some of the academic complexities that the project team faced in developing instructional technology solutions for communications between Virginia Tech and Wake Forest.

Biomedical engineering integrates engineering, life sciences, and medicine with the result that engineering principles can be applied to human medicine. The SBES combines resources of two major universities to create an ideal venue for this new educational initiative. The school is administered jointly by Virginia Tech College of Engineering, the Wake Forest University School of Medicine, and the Virginia-Maryland Regional College of Veterinary Medicine and focuses on collaborative research and educational opportunities for faculty and students on both campuses.[2]

The SBES graduate programs enable students to earn M.S. and Ph.D. degrees in Biomedical Engineering, a joint M.D./Ph.D. degree through the Wake Forest University School of Medicine, and a joint D.V.M./Ph.D. degree through the Virginia-Maryland Regional College of Veterinary Medicine. The mission of the SBES is "to provide a framework for the generation and dissemination of knowledge through research and education for the improvement of human and animal health through cooperative advancements in engineering, science and medicine."[3]

The new school is also aimed at increasing collaboration among researchers and educators in biology, engineering and medicine to advance fundamental discoveries in these areas and foster improvements in health care technologies. Strong institutional support for SBES is acknowledged from the highest administrative levels from both universities. Virginia Tech President Charles Steger commented, "This is a natural partnership between Virginia Tech, which has no human medical school, and Wake Forest, which does not have an engineering school."[4] Thomas K. Hearn, Jr., president of Wake Forest University, said the new school will aid in the transformation of Winston-Salem's economy. "The school will strengthen Wake Forest's intellectual resources, thereby strengthening the capabilities of the Piedmont Triad Research Park."[5] This level of institutional support is critical to the success of the SBES, whose directors work with a wide variety of administrative units such as the graduate school, information systems, and the library in order to create policies and procedures that blend with each institution's requirements.

The State Council of Higher Education for Virginia and the University of North Carolina Board of Governors gave final approval to establish SBES in March 2003. This was a major accomplishment given the challenges associated with creating a school that awards joint degrees

between interstate and public and private institutions. The SBES administrators envision an enrollment of between 80 and 100 students within five years.

Table 1. History of the Virginia Tech – Wake Forest University School of Biomedical Engineering and Sciences

Pre-1999	• An increased number of faculty involved in Biomedical Engineering research within the College of Engineering & College of Veterinary Medicine • Medical Engineering Department formed in Radiology at Wake Forest University School of Medicine
Spring, 2001	• Virginia Tech administrators define a need for collaborative relationship with a medical college • Several Virginia Tech administrations began discussions with Wake Forest University School of Medicine • Executive Summary presented to Dr. Dean and President Steger • Plans begin for establishing the school
Summer, 2001	• Virginia Tech administrators complete a full proposal for establishment of the school • Virginia Tech senior administrators visit Wake Forest University School of Medicine
Fall, 2001	• Approvals obtained from participating departments and colleges • Memorandum of understanding signed between Wake Forest University School of Medicine and Virginia Tech
Spring 2002	• Approvals obtained from the Virginia Tech Graduate School and University Council • Proposal for the SBES presented to Virginia Tech Board of Visitors
Summer 2002	• SBES approved by the Virginia Tech Board of Visitors
Fall 2002	• SBES M.S. and Ph.D. degree programs approved by the Virginia Tech Board of Visitors • Delivery of SBES courses via H.320 (ISDN) interactive video conferencing technology
Fall 2003	• Pilot delivery of courses via H.323 (IP) interactive video conferencing technology
Spring 2003	• SBES and degree programs approved by State Council of Higher Education for Virginia and the University of North Carolina Board of Governors
Fall 2004	• First SBES students admitted into the program • Renovated SBES classroom and delivery of all SBES courses with IP technology

Establish the Teams

The plan to establish the new school was developed based upon the SBES directors working closely with each graduate school dean and key department heads. Two primary teams,

administrative and technical, emerged for the initiative. The administrative team, lead by the SBES directors, provided leadership for securing funding, developing curriculum; complying with graduate school policy and procedures; and recruiting faculty and students. Glenda Scales, associate dean for distance learning and computing in the College of Engineering at Virginia Tech, and John Boehme, associate dean for Academic Computing and information sciences at Wake Forest University School of Medicine, were co-project leaders for launching the distance learning infrastructure in support of the SBES program.

The vision for the technical team was to provide and maintain an advanced stable network and a state-of-the-art distance learning environment between Virginia Tech and the Wake Forest University School of Medicine that promotes educational excellence. Specific goals for the instructional technology team were identified in the following areas: implementing a stable networking infrastructure, designing the distance learning environment, and implementing new instructional technologies. It was extremely important that the curriculum, instructional content and instructional design drove the instructional technology decisions for the SBES learning environment. Therefore, final acceptance of the instructional technology plans included approval from the SBES directors. The team took into account existing technologies as well as the teaching and learning cultures at each institution. The time frame for implementing the technical components of the initiative was aggressive. All project milestones for the initial delivery of SBES courses via IP technology were completed over an eight month period from January 2003 to August 2003.

Goals for the Technical Team

According to Michael and Balraj, there is limited research on the establishment of joint degree programs where two or more institutions contribute resources to provide joint degrees.[6] Offerman further supports this position of limited research available to guide the development of new joint degree programs other than general intuition.[7] The goals and milestones developed for the technical team's plan emerged from the years of prior experience each university acquired from various instructional technology projects. Given that many of the classes in the medical field were very visual, the administrative team looked to the technical team to implement technologies that would provide a media-rich learning environment and reduce or eliminate administrative logistical problems. A detailed overview of the goals is displayed in Table 2.

Networking infrastructure

Virginia Tech and Wake Forest have a long history of being affiliated with state-wide networking initiatives and delivering videoconferencing services. For example, Virginia Tech provides guidance for Virginia's state-wide networking initiative Network.Virginia. Network.Virginia is an advanced, broadband network delivering Internet and Intranet services statewide. It is the result of a project led by Virginia Tech in association with Old Dominion University and the Virginia Community College System to develop universal access to competitive, advanced digital communications services for all of Virginia.[8]

Wake Forest is associated with the North Carolina Research and Education Network (NCREN), which is a statewide Internet Protocol backbone connecting the higher education community within North Carolina to each other and the Internet. NCREN maintains regional points of

presence (RPOP) on the MCNC campus in Research Triangle Park and in Raleigh, Greensboro, Winston-Salem, Greenville, Charlotte, Asheville, Fayetteville and Wilmington.[9]

Both Virginia Tech and Wake Forest have access to Internet2's Abliene network. The motivation for selecting IP for delivering SBES courses was driven by several factors: cost and the ability to move towards future technology. The initial courses for the SBES were delivered in fall 2002 using ISDN. The technical team carefully reviewed the protocol options for delivering future SBES classes. Because of the increasing cost of delivering classes using ISDN and the trend of service providers focusing more on supporting IP, the SBES directors supported the technical team's decision to move to IP.

Table 2. Summary of Project

Summary of Project Goals	*General Strategy*
Networking infrastructure Move away from the ISDN connection toward the use of Video over IP utilizing Internet2	**Identify one individual at each site**. He or she will be responsible for carrying out the vision for the network and overall operations.
Distance learning environment • Identify new distance learning equipment that would reside on both campuses • Desktop conferencing should always be available for faculty and students • Design a state-of-the-art classroom using IP technology	**Identify a network/teleclassroom contact**-one individual at each site. Their responsibility will be to provide assistance/setup during the actual class. Purchase similar equipment for both universities.
Instructional technologies • The ability to view computer generated images with clarity • Support faculty with the conversion of materials • Resolve logistics and access issues for students at both universities	**Identify the instructional technology support group at each site.** Survey the current technologies and procedures used by each institution. **Instructional technology tools** Virginia Tech utilizes the Blackboard platform. Wake Forest University School of Medicine has developed its own web-based curriculum. **Instructional support-** Wake Forest University School of Medicine will provide at least one person to support the faculty with their needs (programming, etc.) and will work with Virginia Tech's Institute for Distance and Distributed Learning. **Instructional designers**- Wake Forest University School of Medicine have approximately five individuals who will help with designing effective material and will work closely with the Institute of Distance and Distributed Learning at Virginia Tech.

The primary goals for the networking component of the project were to make reliable connections using IP technology and to have a contingency plan should the technology fail to work. Our first step with moving to IP technology was for the network engineers to carefully test all points along the network in order to ensure quality. Given that Virginia and North Carolina both have state-wide networking initiatives, the network engineers were able to quickly establish relationships and work with key points of contact to resolve problems.

The network engineers invested a significant amount of time in testing and solving problems related to implementing IP technology. Since this project involved refining the network for a point to point connection using Internet2, there were minimal points on the network to investigate in order to ensure quality of the connection. As the technical team investigates scaling the number of multi-point sessions for the SBES programs, ensuring the quality of the connection becomes more complicated because many of the connections may be on the commodity Internet versus Internet2.

In August 2003 the network engineers were successful in providing video conferencing services using IP. The majority of SBES classes were offered using this technology. The measures of success were:

1. faculty and students did not experience a decrease in picture quality;
2. the stability of the connection was excellent; faculty did not experience any noticeable down time;
3. IP is more reliable than ATM and ISDN relative to packet loss
4. the project also served as a pilot for Virginia Tech as the university transitions from ATM to IP technology in March 2005.

For the delivery of the SBES courses, Wake Forest used a Polycom VS-4000 that can operate up to 2 Mbps over IP to connect to the bridge at Virginia Tech. Wake Forest's SBES courses are delivered from their Telemedicine classroom. Figure 1 depicts the classroom located at Wake Forest.

By connecting to a multi protocol video conferencing bridge, Virginia Tech was able to monitor the classes and provide real-time technical support for the classes as part of their help desk services. As the technical team experiment more with IP technology, the Tanberg 6000 was evaluated for installation in the new SBES classroom, located in 220 Hancock Hall. The Tanberg 6000 has the ability to create multipoint sessions without having to access the bridge. This capability will provide an opportunity for the technical team to continue experimenting with IP technologies.

As we investigate the future use of IP technology for the delivery of courses there are still several areas of concern:

1. authentication;
2. reliability in general, whether across the commodity internet or private internet such as Abliene;

3. the ability of the existing network to support the bandwidth, packet loss and jitter requirements of videoconferencing.

IP technology is the most cost effective mode of delivery when compared to other forms of dedicated service. Additionally, the newer and evolving IP videoconferencing features will provide a more interactive learning environment.

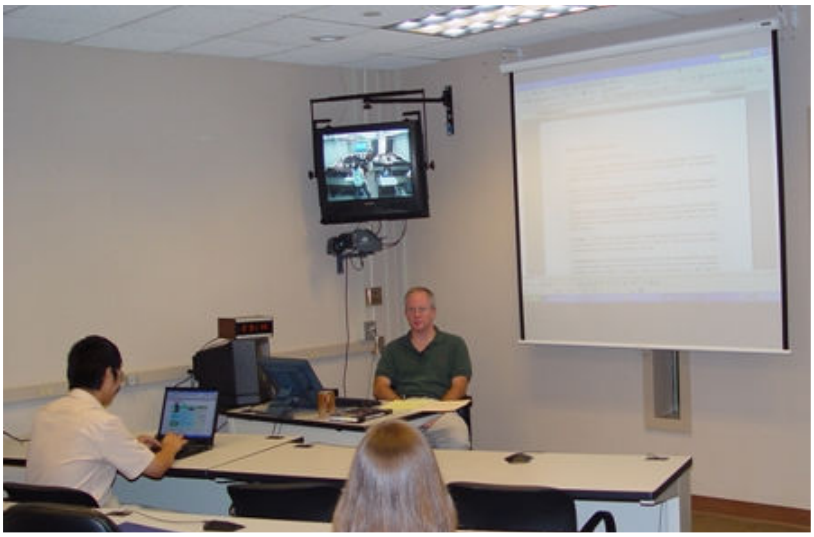

Figure 1. Wake Forest University School of Medicine Teleconference Room

Distance Learning Environment

The initial classrooms for the SBES program house at Wake Forest and Virginia Tech were designed in 2003 using the same technologies at each institution. Each university purchased similar technologies to ensure a consistent learning environment for faculty at each location. The hardware included the following:

1. Wacom Cintiq Tablet. Because faculty required writing equations this hardware was able to compliment the document camera yet provide a way to easily capture the digital image of the equations. This addition to the technology was well received by faculty.
2. XGA Projection System to project the computer display on one screen with the view of the video image on another.
3. Desktop Computers – upgraded to handle new software.

With this initial design faculty experienced a major difference in the visuals from the previous semester. The computer images were displayed via a separate connection from the video. This required projecting the computer generated images and the video image on separate screens. The next phase of the project for the SBES technical team was designing a new IP based interactive videoconferencing room. Based upon the success of the technologies used in the initial classrooms, Virginia Tech and Wake Forest discussed the technologies required for a state-of-the-art classroom to be available for fall 2004 classes.

The challenge with creating interactive videoconferencing classrooms is acquiring appropriate space. As with many institutions, finding space can be the one milestone that will derail a project. To create this classroom an agreement was made between Bevlee Watford, dean of academic affairs at the College of Engineering, and Elaine Scott, interim director of SBES, to share an existing space that is used for the College of Engineering information sessions for prospective undergraduate students. This collaborative effort in space utilization between two distinctly different groups is an excellent example of creating a "win-win" solution.

Therefore the renovation goal was to transform a 40-seat classroom initially equipped with only a computer and multimedia projector into an innovative, interactive video classroom with the ability to provide multipoint sessions using IP technology. Once complete, this classroom would be the first room-base classroom using IP technology at Virginia Tech.

Virginia Tech has a centralized organization that provides support for distance learning initiatives, the Institute for Distance and Distributed Learning (IDDL). Mark Raby, senior associate director for elearning design, delivery and support, who has since retired from IDDL, was a member of the technical team and provided leadership in coordinating the Virginia Tech personnel with the experts from Wire One, a company based in Durham, North Carolina, to renovate the room. Figure 2 depicts a visual of the space targeted for the SBES classroom before renovations.

Figure 2. 220 Hancock Before renovations

The actual renovation schedule for the classroom was to begin mid-June 2004 and to be completed by August 10, 2004, in time for the fall 2004 classes. By working closely with the renovation team at Virginia Tech and the SBES interim director, the Wire One the technical team was able to quickly complete the installation. Lightfoot outlined six primary classroom components as guidelines for designing a multimedia-enabled classroom: [10]

1. computer with adequate disk capacity;
2. permanently mounted video camera;
3. video capture hardware;
4. audio capture hardware;
5. encoding software;
6. wireless microphone and base station.

The technical team included these components as a minimal design and also included several of the optional components described by Lightfoot: omni-directional room microphone, LAN connection for streaming content, integrated podium for instructor interface, and video projection system and screen.[11] Faculty are able to incorporate a variety of interactive learning activities and rich media into their learning environment. For example, virtual office hours and interactive research seminars are now available. Figure 3 depicts a visual of the new SBES classroom. A summary of the room specification is provided in Table 3.

Figure 3. 220 Hancock after renovations

On September 24, 2004, a contingent of Wake Forest University School of Medicine faculty visited the Virginia Tech campus and attended the ribbon-cutting ceremony in the SBES classroom. To celebrate the success of establishing the academic program along with the new instructional technologies, Provost Mark McNamee of Virginia Tech gave the welcoming remarks. Deans Bill Applegate, Wake Forest University School of Medicine and Hassan Aref, College of Engineering Virginia Tech acknowledged the accomplishments of the academic and technical teams from the two schools. Participants located at the Teleconference Center on the Wake Forest campus experienced the ribbon cutting ceremony via interactive video conferencing.

Table 3. Summary of 220 Hancock Room Specifications

Summary of general room requirements	Strategy and Project Outcomes
Room Size	Ensure sufficient room size to handle instructor station, monitor and a larger projection screen as well as accommodate comfortable seating for 40 students.
HVAC	Air handling noise: Too much noise coming from the HVAC. It will need to be reduced for the room to be used for videoconferencing by installing acoustical panels.
Sound	Speakers mounted in the front and back corners of the room.
Data Ports / connectivity	Connectivity consideration included: • Ethernet connection for videoconferencing system; room based computer and accommodate for a portable laptop connection as well; • Student connection for laptops assumed to be wireless (Hancock Hall is wireless capable); • Telephone for trouble calls or connecting someone to the video conference via the telephone; • Point to point calls between Hancock 220 and Wake Forest University School of Medicine ; • Multipoint multi-protocol video conference bridging.
Lighting	Lighting was good; however, special instructor lighting was considered. Blackout curtains recommended for the windows in the back of the room.
Technology	**IP based video** conferencing unit - Tanberg 6000 with epack expansion pack, which is used for additional cameras and video inputs/outputs and allows for the instructor to easily connect his or her laptop into the system. **Monitors** – Two 61 inch flat screen plasma monitors. **Cameras** – Instructor camera; tracking camera for students **Elmo** - Still using the Elmo visual presenter for faculty who require this technology. **Microphones** - Tanberg Ceiling mount Zone Microphones. **Locator mat** – This new technology easily allows faculty to activate the graphics display by stepping on and off the locate mat. The power of this feature will all faculty to concentrate on delivery of their content versus manipulating the equipment. **High lumns** resolution multimedia projector. **Room based computer** and VCR/DVD player. **Physical room security** - Installation of electronic access card reader. **Warranty** required for videoconferencing system.

Instructional Technologies

A key feature of the new learning environment is the ability for the professor to easily interact with students using multiple types of technologies. Learning tools such as Centra One and Blackboard designed for the World Wide Web represent two of the key technologies.

The Wake Forest team worked closely with the IDDL team to coordinate technical support for faculty and students. Additionally, Virginia Tech's Video Broadcast Services group provided recordings of the video and audio to VHS tapes as a convenient backup or archive copy and also encoding for video on demand. Table 4 summarizes a plan created by Kevin Brewer, lead analyst/programmer for the Office of Academic Computing at Wake Forest University School of Medicine to outline the general strategy for blending instructional technologies and processes from both universities.

Faculty Training and Support

During the summer of 2003, the Office of Educational Technologies at Virginia Tech organized Centra One and Blackboard training to assist faculty with teaching at a distance as part of the Faculty Development Institute. There was a joint Virginia Tech-Wake Forest faculty training session held in early August 2003. The series of training sessions gave faculty an opportunity to become familiar with the new equipment before the beginning of fall semester.

Wake Forest sent representatives to the workshops. This allowed the technical and training specialists to gain familiarity with the systems used in the joint program. Virginia Tech staff also provided phone conferences and hands-on orientation for academic computing specialists to gain further experience with the curriculum management and web conferencing products.

Information was delivered to the faculty via two methods: a large group session and individual sessions. The technical team designed the large group session to provide faculty a basic orientation to the technology. Due to various levels of technology skills among the faculty, individual sessions were offered to augment the group orientation. Approximately half the faculty scheduled additional training.

For the first few weeks of class the technical staff was present in the room during every class session to ensure connectivity with the teleconferencing equipment and viability of the conferencing program. Since most courses were facilitated by one or two instructors, the support needs dropped off to only servicing technology problems in the second half of the fall 2003 semester. For the Mammalian Physiology course, the support remained constant because multiple faculty members would teach a lecture series of three to four presentations. Since the faculty rotated through this course and did not spend significant classroom time using the technology, a higher level of support was and remains necessary.

Table 4. Academic Computing Support Plan– Biomedical Engineering Program[12]

Centra One	Process to set up and run a Centra class session. a. Document steps involved in creating Centra accounts for our faculty to lead classes in the teleconference center. Decide if Wake Forest Academic Computing, Virginia Tech, or the faculty will create the accounts. b. Document steps involved in porting teaching materials (PowerPoint) into Centra for the class session. Experiment with some PowerPoints with different functionality, such as animation and motion video, to understand the limitations/opportunities of Centra. Document these limitations and possibilities. c. Document steps for providing the appropriate people (students, Virginia Tech remote sites) access to the Centra session created by a faculty member.
Blackboard	Process to Organize and Upload materials into Blackboard. a. Review the organizational structure of the courses (Mammalian Physiology and Introduction to Biomedical Engineering). b. Consult with faculty on a good organization for materials within Blackboard. c. Initial areas of Blackboard that will be used during this first semester: • announcements • course information • assignments • course documents d. Document methods for uploading materials to Blackboard and where to place them depending on the organization of the course.
Create Documentation	a. Deliver the documentation for items 1 and 2 in multiple formats and media for easy access by the faculty. b. Initial thoughts are e-mail, HTML link from our site, and printed documentation located at the department and teleconference center.
Training	a. Provide additional training sessions for the Biomedical Engineering students on how to access Blackboard and how they will access teaching sessions in Centra.
Support	a. An Academic Computing staff member present until the process is smoothed out.

Lessons Learned

1. Flexibility is the key when supporting faculty. Since faculty have diverse preferences for how to use technology and differing levels of skill, the technical team must constantly adjust the systems to meet their needs.
2. Students adapted to the technology and were able to organize materials from various sources without issue.
3. A diverse technical team requires constant communication and regular status meetings to run effectively. The high level of administrative, technological, academic and faculty coordination dictates a need for clear and frequent communication between the various groups involved at both campuses.
4. Technical documentation is important to allow for redundancy in support across various technology personnel involved in the program – especially when the support is provided from multiple universities.
5. Early involvement of all respective areas within the joint program was a key to success. The early identification and resolution of potential barriers was important in the planning stages of the program.
6. University-level commitment from each school was important in establishing and building the relationship.
7. Software updates need to be factored into support to ensure security and consistency with troubleshooting applications.
8. Establishing a support system and outlining standard operating procedures for connection times should be part of the initial planning stage as well as a contingency plan to accommodate technical problems.

Conclusion

The academic and technical accomplishments for this project were made possible by collaborative efforts among many university-level organizations on both campuses. Given the expertise on both campuses with implementing instructional technology solutions, this project has enabled the technical team to successfully implement a complex project under an aggressive time frame. Today the networking infrastructure is stable and allows the technical team to easily accommodate faculty members teaching SBES courses from institutions other than Virginia Tech or Wake Forest using IP technology.

The technical team's implementation of the strategy and framework for blending technological solutions across institutional boundaries in support of the SBES's academic mission was successful. There were challenges and problem resolution sessions along the way. However, the team managed to work through the issues, learn from one another, and have fun. The success of the technical team with members from Virginia Tech and Wake Forest School of Medicine supports the Michael and Balraj position on the effective use of technology in the implementation of joint degree programs.[13]

> *"Joint degree programs enable institutions to utilize, in more effective manner, the emerging technologies. Computer technology, the internet, interactive video conferencing, and distance-learning technologies have provided a versatile environment for effective incorporation of*

appropriate technologies to enhance students' learning irrespective of distance. Theretofore, it is becoming more feasible for two institutions separated by distance to combine resources through the use of technology to offer joint degree program."

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Biography

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