2006-498: NON-VIRAL GENE THERAPY EDUCATION FOR LUNG DISEASES THROUGH MULTIMEDIA

La Verne Abe Harris, Arizona State University

Bio of La Verne Abe Harris, PhD, CSIT Dr. La Verne Abe Harris came to Arizona State University with many years of industry experience in graphic design, information design, illustration, and computer graphics. Prior to coming to ASU, she was the art director of The Phoenix Gazette, the computer graphics production manager at Phoenix Newspapers, Inc., an editorial illustrator for The Arizona Republic, the creative director of a Phoenix advertising company, and the owner and consultant of Harris Studio, a computer graphics consultation and creative business. As the computer graphics production manager for Phoenix Newspapers, Inc., Dr. Harris managed an international, innovative, interactive computer-graphic department in a joint venture with McClatchy Newspapers of Toronto, Canada.

Dr. Harris is an Assistant Professor of Graphic Information Technology at Arizona State University in the Department of Technology Management. She is also a Certified Senior Industrial Technologist. She received her PhD from the University of Arizona in higher education with an emphasis in sociotechnology, and a minor in media arts. She received her Master of Technology in graphic communications technology and her BA in art education/commercial art from Arizona State University. Before she became an assistant professor in the fall of 2004, she was a lecturer in the College of Technology and Applied Sciences, an appointment she held for five years.

As a tenure-track professor, Dr. Harris has been published in several peer-reviewed journals. Dr. Harris is the 2005 recipient of the Electronic Document Systems Foundation (EDSF) grant, and her paper The Personalization of Data for Website and Print Publishers is nationally and internationally published for industry professionals and academics in higher education. Her paper, The Leap from Teacher to Teacher-Scholar: the Quest for Research in Non-Traditional Fields, was awarded the 2004 Chair Award for the outstanding paper of the American Society of Engineering Educators Engineering Design Graphics Division.

Rajeswari Sundararajan, Arizona State University

Rajeswari Sundararajan received the BSEE (Honors) degree from the University of Madras, India in 1981, the MSEE degree from the Indian Institute of Science, Bangalore in 1988 and the PhDEE from the Arizona State University (ASU), Tempe, in 1993. Currently she is an Associate Professor in the Department of Electronics and Computer Engineering Technology at Arizona State University (ASU), Mesa, AZ. Her teaching and research interests include applications of high voltages for biotechnology and medicine and outdoor insulation aging and contamination studies. Sundararajan was a visiting scholar for the Feinberg School of Medicine at Northwestern University. She is a Member of ASEE and a Senior Member of IEEE. She is very active in several task forces and working groups in IEEE PES and DEIS societies, both as a chair and as a member. She is the recipient the ASU East Teacher of the Year award, and the Associate Editor of IEEE Transactions on Power Delivery.

David Machado-Aranda, Northwestern University Medical School

David A. Machado-Aranda, was born in Caracas, Venezuela. He obtained his MD degree at Luis Razetti Medical School at the Universidad Central de Venezuela in 1998, as a Magna Cum Laude. He continued his education at Nothwestern University in Chicago, IL, USA as a research post-doctoral fellow in David A. Dean's laboratory. Currently he is a resident for the Department of Surgery at Providence Hospital and Medical Center, Southfield, MI.

David A. Dean, Northwestern University Medical School

Bio of David A. Dean, PhD David A. Dean is an Associate Professor in the Division of

Pulmonary and Critical Care Medicine at Northwestern University in Chicago. His clinical and research interest revolves around gene therapy, gene delivery, intracellular trafficking, nuclear transport, asthma, acute lung injury, and intimal hyperplasia. Dr. Dean received his PhD at University of California - Berkeley working on sugar transport in E. coli, and then did his postdoctoral work at UCLA on SV40 nuclear import and viral assembly. His first faculty position was in the Department of Microbiology and Immunology at the University of South Alabama College of Medicine, where he turned his attention to understanding how plasmids enter the nuclei of non-dividing and dividing cells. He moved his laboratory to the Feinberg School of Medicine at Northwestern University in Chicago. He maintains strong ties with the Department of Microbiology and Immunology at Northwestern, as well as the Departments of Cell and Molecular Biology and Biomedical Engineering. His laboratory is at the cutting edge of developing new methods for gene delivery to the lungs and vasculature, which will ultimately lead to treatments for disease targets.

Non-Viral Gene Therapy Education for Lung Diseases Through Multimedia

La Verne Abe Harris, Ph.D., CSIT, Arizona State University
Rajeswari Sundararajan, Ph.D., Arizona State University
David Machado-Aranda, M.D., Northwestern University
David A. Dean, Ph.D., Northwestern University

Abstract

When cutting-edge discoveries in biotechnology research are made, it is important that the information be disseminated throughout the academe, the medical world, and to the public. The understanding of the complexity of the technique can be simplified through the use of multimedia as a form of scientific education. A pilot study is underway at Arizona State University, researching rich media technology for Web-based document distribution for biotechnology education. This study is a collaboration between the Northwestern University Feinberg School of Medicine and Arizona State University's IDeaLaboratory, a creative thinking and usability engineering laboratory.

I. Introduction

The biotechnology, engineering, and medical education community in today's world need informed professionals, who are aware of emerging technological strategies to communicate and disseminate state-of-the-art laboratory procedures, such as non-viral gene therapy for lung diseases. The need for global dissemination of new procedures to a wider audience has resulted in a change in pedagogy on how higher education content is delivered.

Emerging digital technology has been changing the way biotechnological discoveries can be communicated and the way that scientific content can be disseminated through Web-based distribution. When cutting-edge discoveries in biotechnology research are revealed, it is important that the information be disseminated throughout the academe, the medical world, and to the public. The understanding of the complexity of the technique can be simplified through the use of multimedia as a form of medical education. A pilot study is underway at Arizona State University, researching rich media technology for Web-based document distribution for biotechnology education. This study is a collaboration between the Northwestern University Feinberg School of Medicine and Arizona State University's IDeaLaboratory, a creative thinking and usability engineering laboratory.

The scope of this research is exploratory in nature. It will compare two e-learning technologies, address the impact of using e-documents, and will produce usability engineering tools. This research will benefit both the academic world and the business world. This paper will present an overview of the proposed pilot project, summarizing basic media arts approaches that can be used to communicate the research of pre-clinical gene delivery treatment — specifically for non-viral gene therapy for lung diseases. The findings from this study can be applied to graphic presentation of other medical procedures.

The primary objectives of this study are: (1) to define and identify rich media as an emerging technology for Web-based document distribution; (2) to compare the content retention and technology perceptions of the target audience using two e-documents: a static and a dynamic e-document; (3) to develop media assessment tools; and (4) to assess the prototype usability.

II. Significance of this study

The academic, medical, and business communities in today's world need informed professionals, who are aware of emerging technological strategies to communicate and disseminate information. This pilot study focuses on communicating and disseminating state-of-the-art laboratory procedures, such as non-viral gene therapy for lung diseases. In order for the biotechnology professor or researcher to communicate the specific Electroporation (EP) procedure to others, it is helpful for the content expert to know what media arts technologies are available and what their capabilities and limitations are. The university biotechnology experiments and the process of transmitting the information to the university student and the patient through the use of multimedia technologies, will be addressed in this ongoing pilot study.

Academics who would benefit from this study are faculty and students of medicine, biotechnology, bioengineering, biology, engineering, and engineering technology. Graphic technology students studying multimedia and Web usability issues, as well as information design professionals and faculty, can also gain knowledge on the use of media arts technologies for education. Medical professionals and patients with lung disease, who would like to understand this cutting-edge medical treatment, can gain an understanding of the effect of this procedure through the use of computer graphics.

There is also a business use for the findings in this study. In addition to an academic setting, the findings of this research can be applied to industrial training sessions, company advertisement, or in making purchasing decisions for graphic business solutions; for example, CMP Media LLC, a technology and health care publisher, has strengthened it's branding, increased the bottom line, and opened up opportunities to captivate a specific audience through the use of rich media.[1]

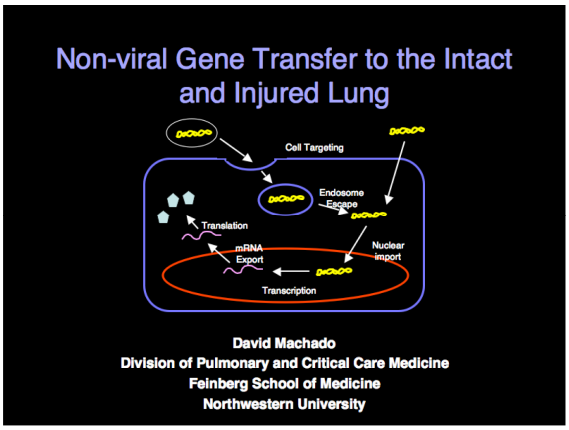
Since the electroporation (EP) procedure that will be presented in the prototypes is one step closer to finding a solution to lung cancer in humans, there is no doubt that this content is significant to not only medical and biotechnology students and professors, but to industry leaders, and the general public. The significance of e-document technology delivery for the university laboratory experience through distance delivery is what this study is all about.

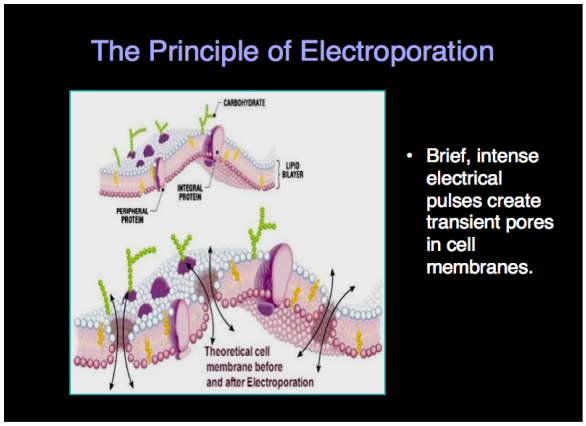
Time is of the essence, when communicating cutting-edge biotechnology discoveries. There is no time to wait for a book to be published. The need for global dissemination of new procedures to a wider audience has resulted in a change in pedagogy on how higher education content is delivered.

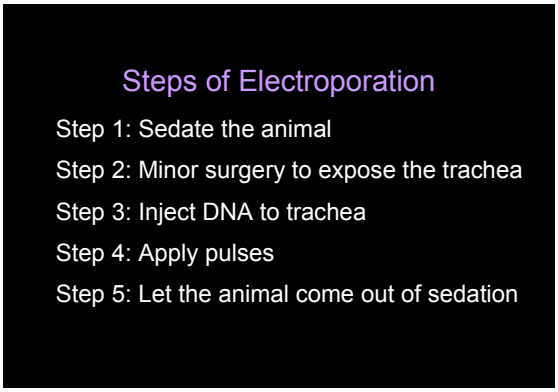
III. How the electroporation technique is being presented today

The emerging biotechnology process of non-viral gene therapy for lung diseases is being presented at academic conferences in the form of static Powerpoint presentations *(Refer to Figure 1)* and static scientific posters *(Refer to Figure 2).*

Figure 1. Pages of Powerpoint presentation

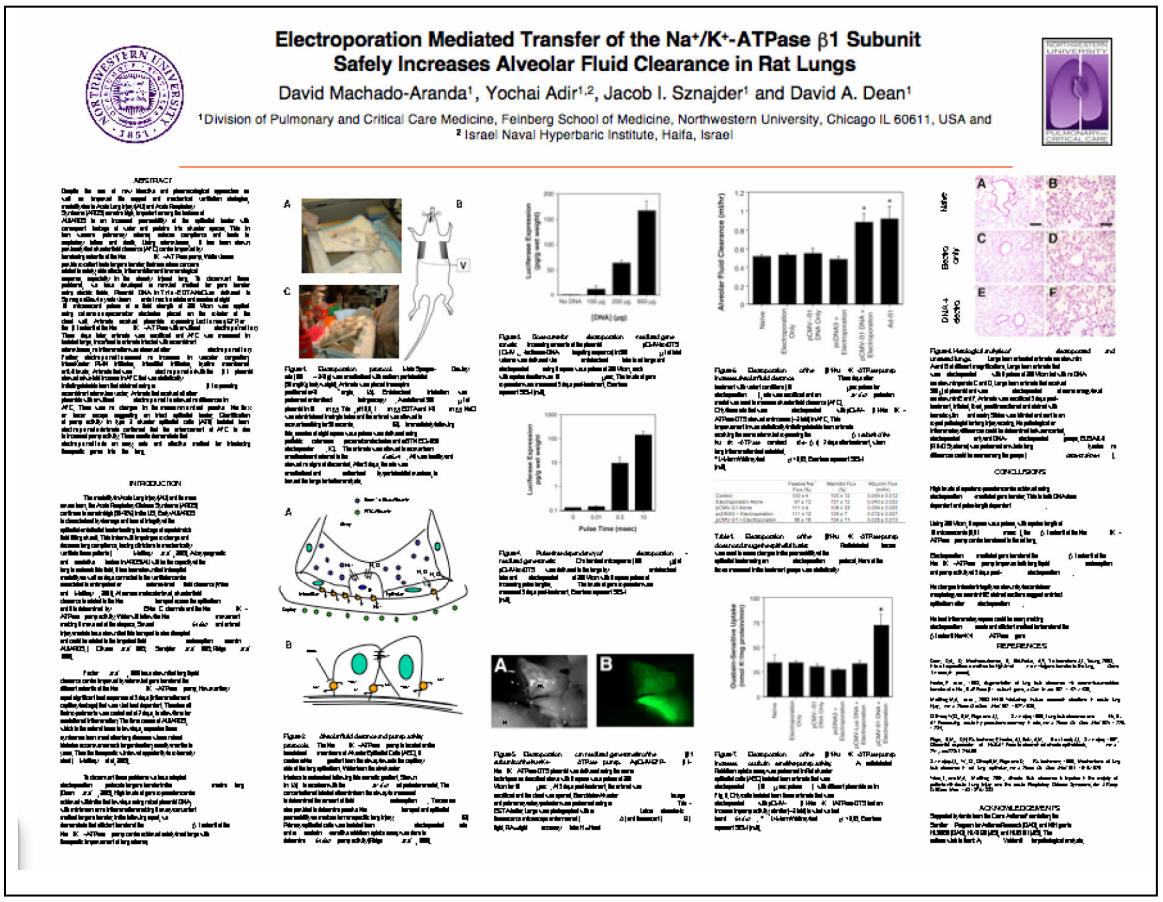






How can new science discoveries, such as non-viral gene therapy, be communicated effectively with a more global approach, both nationally and internationally? The missing element is the collaboration between science and technology — emerging graphic information technology, that is. A collaboration between the Northwestern University medical laboratories and the Arizona State University IDeaLaboratory is proposed to determine the best technical solution to medical content dissemination and to assess the usability of the prototypes developed to produce the rich media learning objects and for the usability engineering process.

Figure 2. Scientific poster presentation



IV. What is multimedia?

In 1990 a US computer journal *Byte* published an article on emerging multimedia technologies and applications, but the definition was evasive. The British magazine *Multimedia: computing with sound and motion* in 1990 referred to the term "multimedia" as "overlapping applications in pursuit of a market and an identity." Ironically, rather than being in search of an identity, multimedia has acquired diverse definitions in a variety of technical fields — from slide projectors with a sound track to computer-generated graphics with sound effects.[2]

Multimedia has been defined as "the combination of words, sounds and pictures in electronic form."[2] It is an exciting way of delivering information and it is transforming traditional methods of content delivery, such as print. Multimedia impacts entertainment, education, government, business, and medical industries. Richard E. Mayer[3] narrowly defines "multimedia" as "words and pictures." The definition that best describes multimedia today is a form of delivering content using more than one media. There are many types of multimedia technology. Some are more dynamic than others.

Microsoft Powerpoint

Microsoft Powerpoint is a slide presentation software that is constantly evolving. In it's simplest format, it can display static slides for the presenter to use as an outline for the presentation. Animated transitions can be added, along with movie clips. A new software called PowerVideoMaker Professional is a solution for converting Powerpoint presentations to DVD-quality video.[4]

Rich media

On-demand rich media is defined as "content that leverages one or more forms of media, such as audio, video, graphics, business documents and other visuals, which is created or developed specifically for use in applications where the intended purpose is specifically for viewing asynchronously, rather than on a live or real-time basis."[5] Rich media is an emerging technology whose definition is evolving. Raw formats are being introduced simultaneously, as old formats become a part of the mainstream. Macromedia Flash, which was recently acquired by Adobe Corporation, is considered rich media, as is Adobe Acrobat PDF format. The PDF file format, not only has been established as the standard for prepress and printing, but it supports Quicktime Virtual Reality rotations, links like a Website, and television motion.[6]

Streaming media

Streaming media is inclusive of both dynamic visual and audio content sent in a continuous stream over the Internet or Intranet. It can be real-time or on-demand access to multimedia content.[7,8] A live event, which is streamed, is called a "Webcast."[9] Streaming media refers to streaming video with sound.[10] The three dominant streaming media architectures today are QuickTime, RealMedia, and Windows Media.[8] True streaming requires a specialized streaming server. Using emerging technologies, such as VBrick products, provide two-way interactive classrooms by creating a television studio, which distributes synchronous demonstrations across the network.[11]

V. What is non-viral gene therapy?

Almost all events and interactions involved with the human body are ultimately electric in nature. Electroporation (EP), which is often called "electropermeabilization," is a non-viral, physical technique that involves the application of electrical voltage pulses of high intensity and short duration that temporarily and reversibly open the normally impermeable plasma membranes of the cells, allowing macromolecules to pass through. This alternative gene delivery treatment for lung diseases is currently being researched at Northwestern University Feinberg School of Medicine.[12] The approach uses electrically-mediated non-viral physical gene therapy – – specifically, in vivo using rat and mouse animals, through the optimization of the electric pulses *(Refer to Figure 3).*

Figure 3. Mouse in vivo electroporation

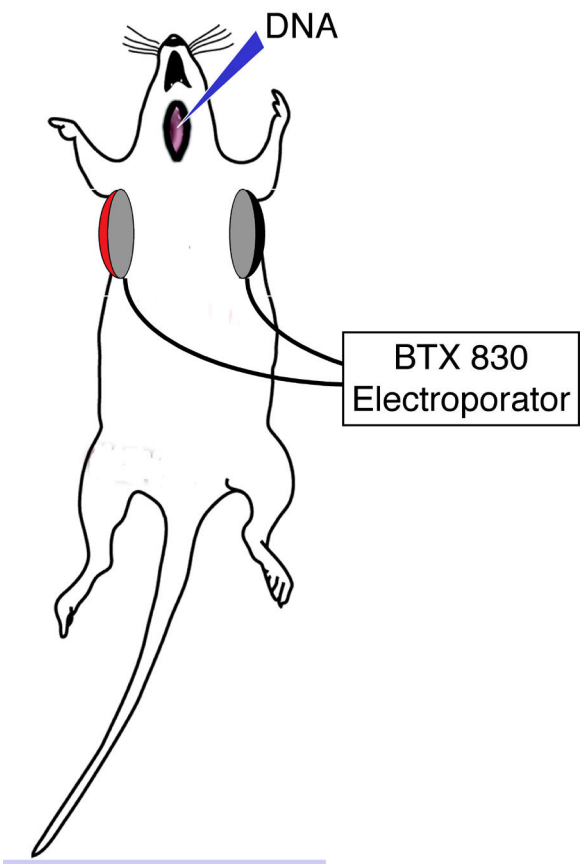


Illustration of in vivo electroporation procedure for mouse lungs (Dean et al., 2003).

• A volume of 100-200 µl of a DNA solution was injected into the trachea, which was exposed through a small incision in the neck, and allowed to distribute throughout the lungs by holding the animal upright.
• The chest was wetted with 70% ethanol and within 30-60 s of DNA delivery.
• Electrodes were placed on either side of the chest and the animal was electroporated. The electroporation conditions used were: eight square voltage wave pulses of 10 ms duration each at a field strength of 200 V/cm and at 1 s interval.

The development of non-viral methods for efficient gene transfer to the lung is highly desired for the treatment of several pulmonary diseases. David Dean and David Mechado-Aranda at Northwestern University have developed a noninvasive procedure using electroporation to transfer genes to the lungs of rats and mice. During 2005 Rajeswari "Raji" Sundararajan of Arizona State University was a visiting scholar in the Feinberg School of Medicine at Northwestern University. She worked with Dean and Mechado-Arnada in the laboratory. The results of the experiments provided evidence that electroporation is a safe and effective means of introducing DNA into the lungs. The findings from this experiment form the foundation for further lung disease studies that can be applied to human beings.

Purified plasmid (100-600 microg) was delivered to the lungs of anesthetized rats through an endotracheal tube, and a series of square-wave pulses were delivered via electrodes placed on the chest. Relatively uniform gene expression was observed in multiple cell types and layers throughout the lung, including airway and alveolar epithelial cells, airway smooth muscle cells, and vascular endothelial cells, and this finding was dose- and pulse length-dependent. Most important, no inflammatory response was detected. These results demonstrated that

electroporation is an effective method to increase clearance by introducing therapuedic genes into the rat lung.[13]

VI. What is the IDeaLaboratory?

The newly-formed IDeaLaboratory — often referred to as the "IDeaLab" — is an interdisciplinary content-independent lab at Arizona State University at the Polytechnic campus in Mesa, Arizona. The laboratory was formalized as a response to the call to action report from the National Innovation Initiative.[14] The adoption and acceptance of information technology (IT) in our corporate and industrial culture, has resulted in the social construction of IT in the marketplace. Since the IDeaLaboratory stems from the Graphic Information Technology program in the Department of Technology Management at Arizona State University, it stands to reason that the IDeaLaboratory embraces technology-based solutions with ethical considerations for industry-based problems.

The lab is dual in purpose and target market. It has the dual role of being a university design, technology, and usability research laboratory, and a media design unit. It examines the role of human factors on innovation, design, and technology through problem-based learning with computer-based solutions. The IDeaLaboratory is designed to support collaborations with visionary leaders in the university and private sectors.

Arizona State University Polytechnic campus mission includes integrating practical and theoretical study, and engaging in research that emphasizes problem solving, ethics, and knowledge that is applied. Situated in the Department of Technology Management (DTM), the IDeaLaboratory embraces the DTM units of Graphic Information Technology, Operations Management Technology, Global Technology Management, Environmental Technology Management, and Fire Service Management and Administration. The interdisciplinary nature of the IDeaLaboratory offers opportunities for the other Polytechnic campus units, such as Engineering Technology, Computer Studies, Humanities and Arts, Business Administration, Applied Psychology, Education, and Agribusiness. The IDeaLaboratory is set up to work collaboratively with Engineering Design Studios on the Polytechnic campus, the Computer Studies Lab, and the InnovationSpace on the Tempe campus.

Roles of the players

Academic and Medical Collaboration
Arizona State University's La Verne Abe Harris, Ph.D., and Rajeswari Sundararajan, Ph.D., in collaboration with Northwestern University Feinberg School of Medicine's David Machado-Aranda, M.D., and David A. Dean, Ph.D. will determine the content for the prototypes.

IDea Scientists
A team of hand-picked "IDea Scientists" from Arizona State University's IDeaLaboratory: Adam Lessell, Jaret Lynch, Brandon Beecroft, Dustin Watson, and Ignacio Marcos Lujan, are working on this independent study under the direction of Dr. Harris. Four of the IDea Scientists are undergraduate students majoring in Graphic Information Technology. Lujan is a graduate student in the Master of Science in Technology program with a concentration in Graphic

Information Technology.

The IDea Scientists will work under the direction of Dr. Harris for university course credit to research Web-based solutions to medical content dissemination, produce the static and dynamic Web-based prototypes, create usability engineering tools, and assess the usability of the prototypes.

ASU Laboratory Collaborations
The IDeaLaboratory is set up to work collaboratively with ASU's Engineering Design Studios, the Computer Studies Lab, the InnovationSpace, the Student Web Development Enterprise (SWDE), the Graphic Information Solutions (GIS) print shop, and the Digital Photography Laboratory (DPL).

Industry partners
Along with the academic and medical collaboration, the IDeaLaboratory has industry partners have committed to participate in the focus groups and mentor the students. They consist of industrial leaders at Honeywell, Motorola, Intel, Boeing, and google.com.

VII. Virtual laboratories

E-learning has become an alternative method of course delivery in the university in order to globally disseminate academic content. It is not new to the academe. The concept of distance learning began many years ago with correspondence courses. Many doctors and potential graduate students work or live far away from a research university, and need access to emerging scientific discoveries that are not limited by geographic boundaries.

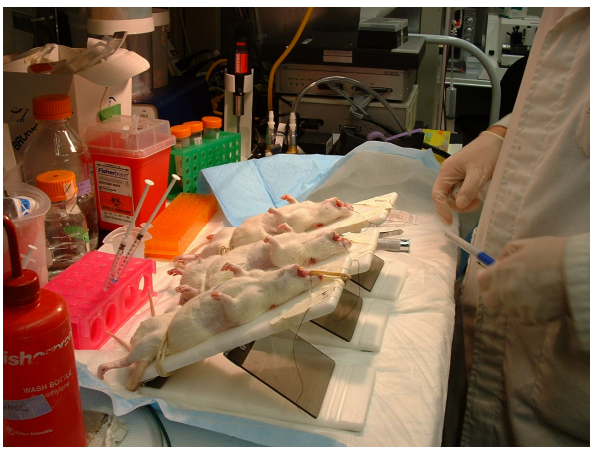
Emerging technologies, such as rich media can be used to exploring ideas and methods to maximize the university laboratory experience through distance delivery. A few universities are using the Internet to disseminate the scientific laboratory experience. In 2008 Weill Cornell Medical College – Qatar branch will graduate its first streaming video-trained doctors. Qatar is on the west coast of the Arabian Gulf.[15] The University of Washington[16] and the University of Otago's Christ Church School of Medicine in New Zealand[17] have also joined the instructional online technology movement.

Many universities, such as Wayne State University's School of Medicine[18] and the University of Arizona's medical school[19] have their own Media Production Department to produce, direct, edit, and write both audio and video projects.

One challenge facing research-focused institutions offering biotechnology, medical, or bioengineering degree programs is the expense of building and maintaining laboratories. If an emerging scientific laboratory experiment, such as non-viral gene therapy, could be demonstrated online and explained in detail in a rich media format, the information could be disseminated on a global scale. The "touch and feel" experience of the laboratory can be simulated with a rich media asynchronous experience *(Refer to Figures 4 and 5).*

Figure 4. Screen shot of a QuickTime movie of the rat in vivo electroporation

Figure 5. Photos of the rat in vivo electroporation



IIX. The next step

Medical doctors and professors may be resistant to the use of emerging graphic information technologies in the delivery of their laboratory experiments, because they have do not have the time, technical skills, software or hardware to create a multimedia learning object. Faculty argue that the university promotion and tenure review process does not reward the creation of instructional design.[20] In many institutions there is a lack of instructional design support or time allocated for faculty development.[21]

That is where the IDeaLaboratory comes into play. The IDea Scientists will be a part of the initial decision-making process on how to solve the dissemination of the non-viral gene laboratory experiment using a technological solution. In 2006 the IDeaLaboratory brainstorming think tank pods will be formed with students and industry leaders under the direction of Dr. La Verne Abe Harris. A static prototype and a dynamic rich media prototype will be developed and assessed through usability surveys and focus group discussions. The results of the study will be presented in the next paper.

Prototypes

The two e-document prototypes produced will contain the same content, but the approach used to deliver the content will differ. Prototype A will be a static Powerpoint e-document on the electroporation (EP) procedure used in the non-viral gene transfer for lung diseases. The same content will be used in producing the Prototype B, which will be a dynamic rich media presentation. The research conducted will determine the software packages used to develop the module.

Classroom Participation Groups

Two participation groups consisting of college students will be asked to participate in the identical content pre-test. One group will view Prototype A. The other — Prototype B. Then a post-test will be given on the content and usability. The content portion of the tests will be identical.

Usability Evaluations

The usability of an online Web-based e-document is a significant indicator of its success. Because feedback on the ease-of-use issues is imperative, and because two models will be compared and analyzed, a lab-based, focus-group from the IDeaLaboratory will be in place. These evaluations will be used in controlled usability assessments and will consist of face-to-face sessions with students, faculty, staff, and industry leaders, and will follow the pre- and post-tests.

Traditional lab-based usability assessment is an accepted testing methodology in most design and technology organizations. It involves one-on-one moderated sessions with no more than 20 participants. The qualitative research focuses on observations and feedback from the participant.

Following the face-to-face empirical research, a features matrix will be implemented, which will indicate weighted perceptions and interview feedback in order to gain information on the following: (1) The usability of the technology on the participant; (2) Observations; (3) How

effectively site tasks are accomplished by online users; (4) How effectively the technology is transferred to different businesses; (5) The perceived value of the technology by the participants.

Participants will be asked relevant follow-up questions on their ability to complete a task, whether the problem is related to readability, functionality, nomenclature, or navigation. These one-on-one, 60-90-minute sessions will include video captures and/or sound recording for future analysis. The key tasks and the order of the key tasks may change, based on the input of the participant.

VII. Summary

The collaboration between the Northwestern University School of Medicine and Arizona State University's IDeaLaboratory will result in the marriage between an emerging cutting-edge medical procedure and emerging graphic information technologies. Interdisciplinary and inter-university projects, such as the non-viral gene therapy prototypes are beneficial for medical and industry professionals, academics, students, and eventually for patients.

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