

Project Description

1. Identification and Significant of the Innovation

Azul Business Corporation proposes to develop a multimedia system for the aggregation, synchronization, and distribution of an educational instructor's classroom presentation for the purposes of providing a student with an easily accessible instructional replica of the instructor's performance. This presentation will encompass both the content written by the instructor, and the content spoken by the instructor. The innovation occurs in how the content is stored and presented. Vector-based graphics will be utilized to create a presentation that is scalable and compact. Gesture recognition will be utilized to allow the teacher to command the software remotely from the digital whiteboard. Time encoding will be utilized to synchronize the graphical and audio content. This tool allows the teacher to seamlessly author content for their students by recording the in-class presentation. There is minimal additional effort on the instructor's part to distribute this content to the students and minimal impact on the instructor's previous teaching style, ensuring a higher rate of utilization across the board.

2. Background and Phase I Technical Objectives

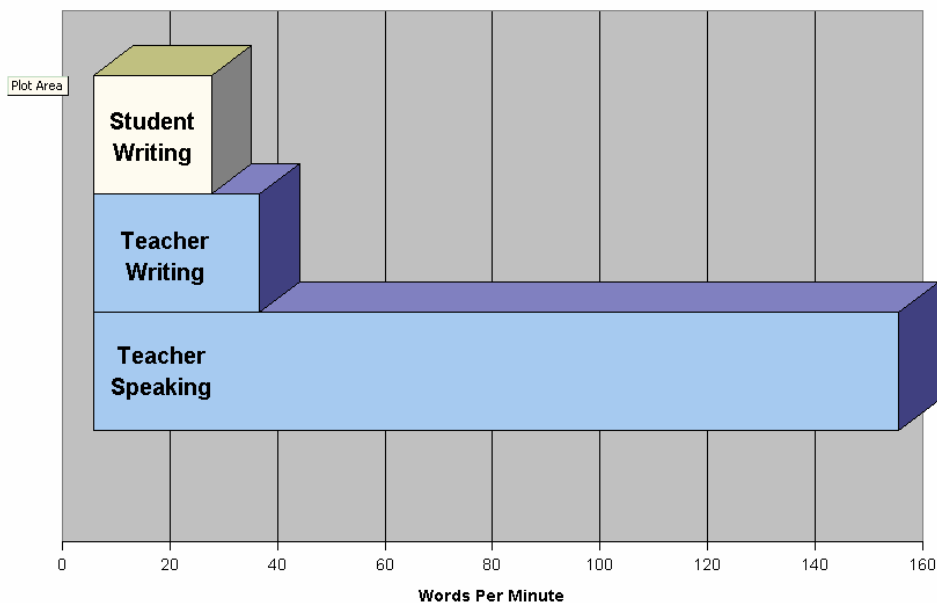
In conventional wisdom, a college student should spend three hours reviewing and studying for ever one hour spent in class to succeed in that class. For all learners, repeating and reinforcing the material is essential to fully grasping the topic. Without multiple exposures to the information, the student will not be able to maintain a long term memory of the topic material. Current instruction techniques offer little help for a student trying to study outside of the teacher's direction. Either the students are forced to teach themselves from textbooks, forced to go to the teacher for additional tutoring, or forced to work from their personal lecture notes.

All of these current options are insufficient for the needs of the student. Textbooks offer only one perspective on the material being learned, and fail to account for the specific background of the student, and the specific goals of the course. Effective instructors will use textbooks as reference materials, and specifically tailor their instruction to meet the needs of the specific topics being discussed as well as customizing the methodologies to concur with their own teaching styles. Tutoring is expensive in terms of man-hours due to an instructor having limited time outside of regularly scheduled classes to spend with their students, especially considering the trend towards larger class sizes in the introductory levels of college education. Furthermore, personal tutoring fails to help any other student in the class besides the one being tutored.

Studying from lecture notes taken personally by the student is the most prevalent method used by students to reinforce the professor's lesson. While these are taken directly from the professor's direct instruction, it is impossible for a student to be able to transcribe all

content given by the professor. According to studies, the average rate for effective speaking is 150 words per minute (Williams, 1998), and the average rate for writing from memory is 31 words per minute (Brown, 1988). This means that an instructor that is both lecturing and utilizing a chalkboard or whiteboard would be delivering information at an approximate rate of 180 words per minute. Unfortunately, a student will only be able to record unfamiliar material at a rate of 22 words per minute (Brown, 1988), leaving a huge gap between what is taught and what is preserved for study outside of the classroom.

Language Rates in the Classroom

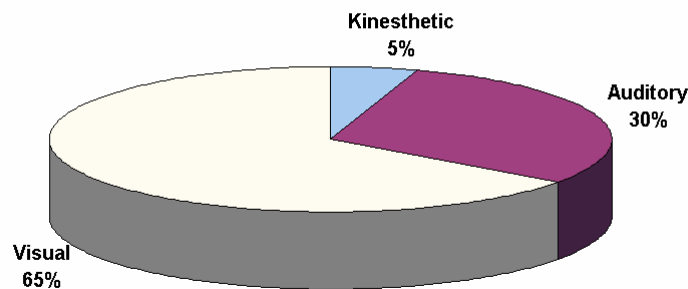


Additionally, lecture notes offer only a static view of the content. In curriculums such as history, this may be acceptable since the majority of the facts can be understood independent of each other. In curriculums such as mathematics, this is not the case since techniques are based around several related steps that can not be comprehended without comprehending how they relate to each other. It is necessary to grasp each of the progressive and iterative steps of a given problem solving technique. Common sets of problems have common sets of techniques to solve them, but if the students sees only a fixed picture of the problem, the steps, and the answer to the problem they will not be able to understand the critical decisions made to achieve the final solution. To parallel this with everyday driving, this is akin to being shown photographs of street signs without being told where or why you're turning or how this helps you get where you're going. While mathematics students may be able to record the work the professor does in class, they lack the professor's narrative and pacing that provides guidance, instructions, and detailed explanations of what and why they are doing what they are doing.

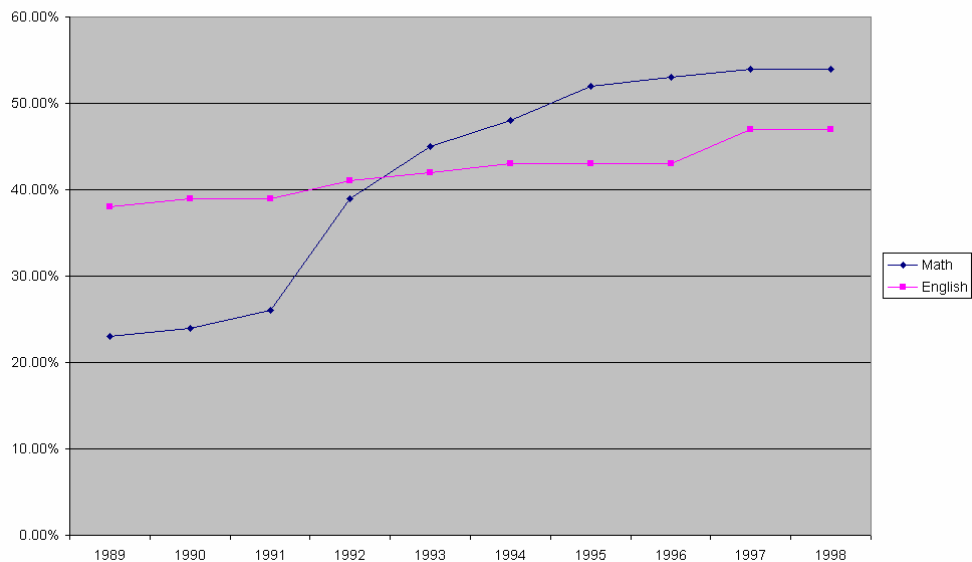
The static nature of notes impedes many different types of learners. Sixty five percent of learners are classified as Visual learners, where they learn best by watching. Although

notes serve this portion of learners the best, they still are impeding by the lack of demonstration of the step-by-step processes during their study time. Thirty percent of learners are classified as auditory learners who learn best by hearing the material spoken to them. Nothing about notes will help these learners, and they have a considerable amount of difficulty learning without hearing the professor's lecture. The remaining five percent can best be described as tactile learners who learn through the use of hands on activities. They are difficult in any situation to teach, and learn math best by hands-on demonstrations of the material. (Mindtools, 2004)

Frequency of Learning Styles



Freshman Requiring Remediation at California State University



We specifically target the mathematics curriculum both because of the aforementioned step-by-step problem solving nature, and because of the severe need for improvement in the success of mathematics students. Introductory college level math courses have become an increasingly difficult hurdle for incoming students to get over. In many colleges surveyed, the failure rates for college algebra were over 50% (Austin Community College, 1998)(CSU, 1998). Worse than that, the trend has only gotten

worse. At California State University, the number of students needing remedial math help, that is needing to take math courses below the minimum expected skill set of an entering freshman, has taken a sharp rise over the last decade. In just ten years, the number has more than doubled from 23% to 54% needing remediation. Comparatively, English remediation has only had a small rise from 38% to 47% over the corresponding time frame. (CSU, 1998)

Current solutions for classroom technology are insufficient to properly meet these needs. The widespread use of digital projectors and slide show presentations across most academic subjects only offer static, inflexible views of information. This allows no iterative explanations of problems, no dynamic changes done by the professor, and no interaction with the class. This is completely insufficient for problem solving and is why this solution is rarely used for algebra, calculus, and other beginning college level math courses.

Video cameras have been around for decades, but have yet to find a place in the math classroom. Video cameras have to be operated by a technician, which is an expensive overhead to incur. Worse yet, the video recordings frequently poorly reproduce what has been written on the board due to lighting conditions, resolution, angle and a myriad of other factors. Also, placing a video camera in the classroom will negatively effect the involvement of the students in the discussion due to issues of stage fright and nervousness. Finally, it is difficult if not impossible to distribute a video tape to dozens of students in time for them to study the classes lecture within a reasonable time frame.

A recent advancement in education has been the use of satellite and internet-based courses to record and distribute the content to students over multiple locations. Old Dominion University has developed a program called TELETECHNET to do just this. As implemented, TELETECHNET requires a specially constructed \$50,000 classroom complete with multiple videos cameras, a full-time technician, dozens of microphones, specialized lighting, and half a dozen high-end computer servers to encode the video and audio and to stream it over the internet and through the satellite dish uplinks. This is all required on a per classroom basis. As a result, ODU has needed half a dozen of these specially developed classrooms, and had to construct a specialized building to house them. TELETECHNET is a fantastic program for what it is, but it requires a multi-million dollar commitment to build and operate. Furthermore, it imposes difficult restrictions on the teacher's methodologies, since not every technique can be recorded by the cameras, and in fact the teacher is not allowed to leave his chair for the entirety of the lesson. Even after all these advances, the output for students repeating the lectures outside of class still remains a small, grainy video stream over the internet that is over 275 megabytes for three hours worth of class.

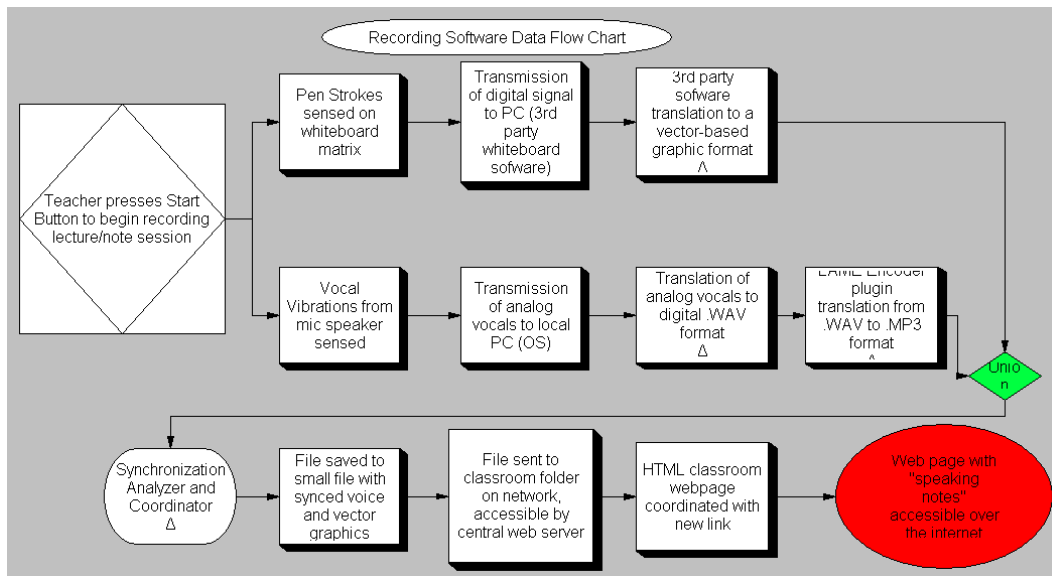
We choose to solve this problem by recording the professor's narrative lecture using a wireless microphone and the professor's written notation using a digital pressure sensitive whiteboard. This content will then be synchronized together, stored in an efficient format, and distributed via the internet to students for playback on their own computer of use. We term this solution Student Audio/Visual E-tool or SAVE.

The key topics that need to be addressed in our Phase I research involve the technical feasibility of the project. We need to determine and demonstrate the best ways to handle vector-based interpretation of the whiteboard input, to synchronize the whiteboard input with the audio input, to interpret drawn gestures on the whiteboard as command input, and the ability to store the entirety of this data in a compact format for distribution.

Vector-based recording will allow us to have a high quality graphical reproduction and also be able to store the graphical data in a format that will be one hundredth to one fifth the size of other graphical storage formats. Synchronization is integral to being able to replicate the presentation in a coherent format on the students own home computer. Drawn gestures are a very significant innovation and will allow the teacher to send commands and instructions to the recording software for purposes of content control and authoring without interrupting the flow of their instruction. Developing gesture recognition technology will allow us to seamlessly integrate this with our product. Storing all this data in an appropriate format is necessary to be able to distribute this file over the internet to the students for their own personal study time.

3. Phase I Research Plan

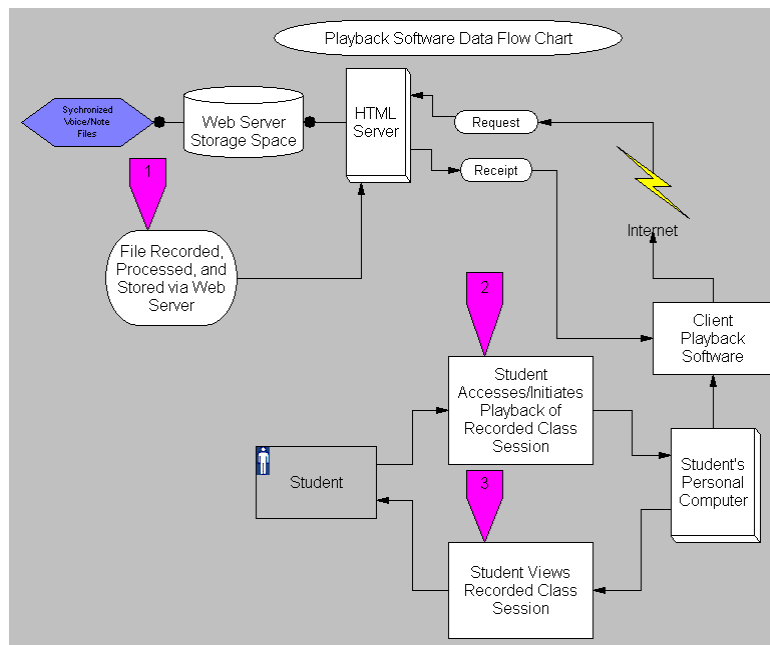
The core of the SAVE project is being able to deliver the instructor’s presentation from the classroom to the student. As such, the project can be broken down into three major conceptual areas. First, there is the software and hardware architecture necessary for recording the instructor’s presentation. Secondly, there is the distribution mechanism to deliver the data to the student. Thirdly, there is the playback software on the machine the student is using.



The recording functionality needs to interpret both the graphical and audio portion of the presentation. The graphical portion is captured by the use of a digital whiteboard. This

whiteboard is connected to the classroom computer which has our recording software running on it. All pen strokes on the digital whiteboard are translated from the whiteboards native format into our proprietary vector-based format. The audio will be transmitted from a wireless microphone worn by the professor to the classroom computer's sound input. This will be encoded into a compressed mp3 format at a constant bit rate suitable for spoken word recordings.

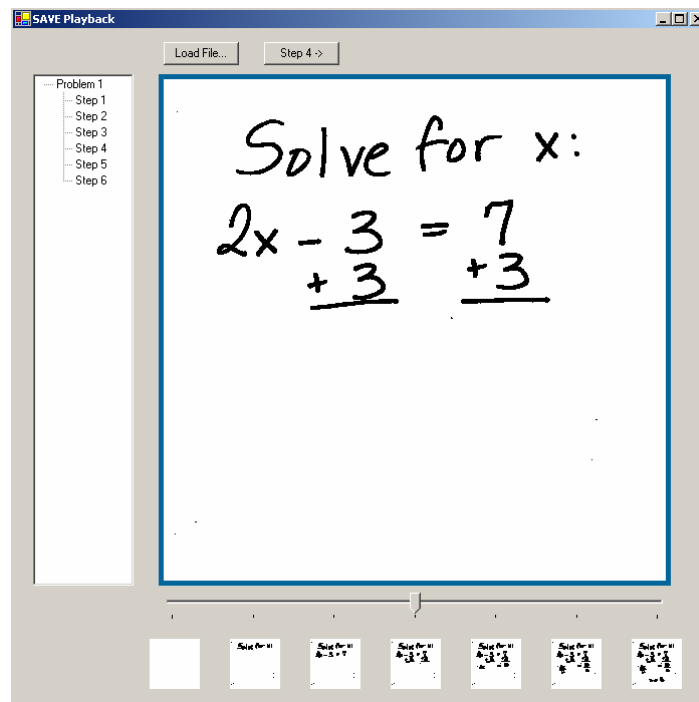
We will have on the whiteboard a specially designated "Command Square." Anything drawn by the instructor in this special portion of the whiteboard will be interpreted by our software. Certain shapes or lines will be interpreted as commands from the instructor to our software. A specific sequence of lines, such as three lines forming a triangle, will be interpreted by our software to mean it should divide the playback into a new problem. Another sequence of lines, such as circle, would mean the software should further segment this problem unit into an individual step sub-unit. Another sequence could be used to pause the recording, and another could be used to restart the recording. By use of such gesture recognition technology, we allow the instructor to control the content flow of their presentation without interrupting the lesson by leaving the whiteboard. No interaction with the computer will be required after the initial software is setup. We feel this is an important innovation, and allows a considerable degree of simplification of the content authoring process.



In the distribution chain of events, we start when the instructor completes the lesson. The recording software will finalize the encoding, and offer the instructor additional customization options for the file, such as naming it and providing a short description. After the file is complete, the software will ask the instructor where to upload it. The software will then upload the file to the designated server. This server will be running software designed as part of the SAVE project designed to handle these presentation files. This server software handles uploads from instructors remote machines, and stores it for

future retrieval. Students will access the presentation files by logging into the server and accessing the specific class they want notes from. Control of content distribution will occur by this software to allow only authorized students to access the content. Once logged in, the students will be able to either download the file to their local computer, or play it back on the website itself.

The playback software will either be a standalone program installable on the students machine, or a web-based application based off of languages such as Java or Macromedia flash that are capable of operating within a users internet browser. Both types of software will be developed to ensure maximum interoperability. The software will open up the file, and decode it and play it back



Initially, we need to demonstrate the practicality of taking the pressure sensitive input from the digital whiteboard and converting it to vector format. The majority of digital whiteboards on the market employ raster-based graphics. This stores and transmits the image on a pixel by pixel basis. The problems with this format are that it does not scale well to show fine detail, and that it is difficult to store this information in an efficient manner since the end output would take the form of a full motion video. This would quickly grow to an unmanageable size. Each unit of vector-based data stored in our proposed solution would describe an individual pen stroke, including start point, end point, color, start time, and end time. This information would allow us to redraw in real-time the exact writings of the instructor.

Next, we need to take the coded graphical input and the audio input and ensure that it is possible to synchronize the two streams. To ensure this, every vector stroke recorded being drawn will have a time stamp attached to it signifying at what specific point in time

in the presentation this stroke was drawn, and the duration of time until the stroke was completed. This will allow us to know when every single pen stroke was drawn precisely. Furthermore, since we are using a constant bit rate audio stream, we will be able to match the sequence of event to the audio being played simply by determining the time into the presentation the audio was recorded.

Now, we need to develop a gesture recognition technology to enable the teacher to be able to control the recording software. Since at this point we have already decoded the graphics into vector strokes, we can match these strokes against a library of recognized commands. Each command drawing will have very characteristic vector strokes associated with it. For instance, a square has four connected vectors, two vertical lines, and two horizontal lines. A robust implementation of this technology will account for variances in drawing styles without misinterpreting what is drawn. Since we have only a few commands that need to be recognized, and a pre-defined Command Area, there should be a very low false-positive rate.

Finally, we need to store the audio and graphical data into a compact file format. This will be accomplished by encoding both the audio and graphical data on the fly during the presentation. The audio will be encoded as a series of small mp3 snippets, each one corresponding and identified as belonging to a specific step or problem within the presentation. The graphical data will be stored as a list of vector pen strokes with associated time stamps and other information. Each segment of the presentation, whether it be a problem or a step within a problem, will have an associated list of vector pen strokes.

Phase I has several critical steps that will be shown to have been achieved at the end of Phase I. Each individual objective, once accomplished, should be demonstrable. Obtaining the graphical data in a vector format will be proven by displaying the whiteboard output in a vector output on the connected computer screen. The synchronization will be proven by not only displaying the vector data, but correctly having the recorded audio match up with and playback with the graphics. The gesture recognition technology will be demonstrated by having software that takes in the vector strokes drawn, matches the pattern against a library of known gesture commands, and alerting the computer user as to which gesture was drawn. Accuracy of the gesture interpretation software can be determined at this point. Finally, once all of this data can be written to file, and successfully have all of its information retrieved from, we should be able to see the results on-screen in the same ways as the previous objectives.

4. Company Information

Azul Business Corporation

"Our mission at Azul Business Corporation is to improve the quality of education by implementing technology into schools particularly those technologies that help the many different styles of learning. Our products are built to integrate easily into current systems and be used without excessive training. Students and Professors that take

advantage of our products will see an increase in the student's ability to learn material by emphasizing repetition and allowing access to classroom lectures."

Azul Business Corporation was founded in 2004 when six Old Dominion University Computer Science students formed a group in their CPI (see below) class. The company's first product was initially called The Invisible Blackboard. After conception the group decided that the name was misleading to what the product will accomplish thus, our product found a new name in an acronym,

SAVE, The Student Audio Visual e-Tool.

We plan on incorporating this tool into many classrooms to encourage students to study and review more, improving education. Technology is become more and more dominant in schools today. We are striving to be the best and first choice of schools across the nation when upgrading their technology needs in the classroom. We believe that with the introduction of our product into a school students will be more inclined to review material taught. We provide a clear investment for education. By decreasing failure rates the school may see an increase in enrollment due to the quality of the resources and education they will be providing with our products.

Computer Product Initiative (CPI):

The Computer Productivity Initiative (CPI) began as a research project that was supported by the National Science Foundation as the first attempt of tying together a Computer Science set of curricula courses by providing a project based course sequence that required the knowledge and skills previously learned. Since the completion and reporting of the research success, several courses of a similar nature have been developed and placed in use as part of the curricula of other universities. All information on this site pertains to CS410 projects at Old Dominion University. If any questions arise, please contact our Professor Dennis Ray.

5. Commercial Potential

While there are many applications for our product, we still have a specific audience in mind. We would start with this specific audience and expand to a different or modified audience in the future.

Who is the Customer?

The target market for our product is university mathematics departments. Our target market includes the more than 2100 public and private four-year colleges in the United States.¹

A search for public or private four-year colleges in Virginia offering a degree in mathematics yielded 39 matches on Peterson's Education Portal.

¹ From Peterson's Education Portal. Available at: <http://www.petersons.com>

Averett University, Bluefield College, Bridgewater College, Christopher Newport University, Eastern Mennonite University, Emory & Henry College, Ferrum College, George Mason University, Hampden-Sydney College, Hampton University, Hollins University, James Madison University, Liberty University, Longwood University, Lynchburg College, Mary Baldwin College, Marymount University, Norfolk State University, Old Dominion University, Radford University, Randolph-Macon College, Randolph-Macon Woman's College, Roanoke College, Saint Paul's College, Shenandoah University, Sweet Briar College, University of Mary Washington, University of Richmond, University of Virginia, University of Virginia's College at Wise, Virginia Commonwealth University, Virginia Intermont College, Virginia Military Institute, Virginia Polytechnic Institute and State University, Virginia State University, Virginia Union University, Virginia Wesleyan College, Washington and Lee University, The College of William and Mary

Initial Customer

Our initial customer is the Old Dominion University (ODU) Mathematics Department. ODU offers a B.S. in mathematics, M.S. in computational and applied mathematics, M.S. in mathematics education, and a Ph.D. in computational and applied mathematics. All undergraduate students are required to complete at least three credit hours of mathematics:

- MATH 101M An introduction to mathematics for critical thinking
- MATH 102M College algebra
- MATH 162M Pre-calculus I
- STAT 130M Elementary statistics

Depending on a student's major, (ex. computer science, engineering, physics, etc.) more mathematics may be required.

ODU has 20,802 total students. Among those 14,209 are undergraduate students and 6,593 are graduate students.²

Return on Investment for Customer

This solution provides an easier and better way for students to see and hear the lecture again. It does not require one or more cameras. It will allow students to resize the presentation to their preferences.

Benefits to Instructors

Instructors can conceivably cover more examples of problems in the lectures. At Old Dominion University, MATH 102M (College Algebra), 162M (Pre-Calculus I), 163 (Pre-Calculus II), 211 (Calculus I), 212 (Calculus II), and 307U (Ordinary

² From ODU Campus Facts. Available at:
http://www.odu.edu/webroot/orgs/IA/university_news.nsf/campusfacts?OpenForm

Differential Equations), administer common exams. These means that all instructors in each course are expected to cover the same material during the semester.

Benefits to University

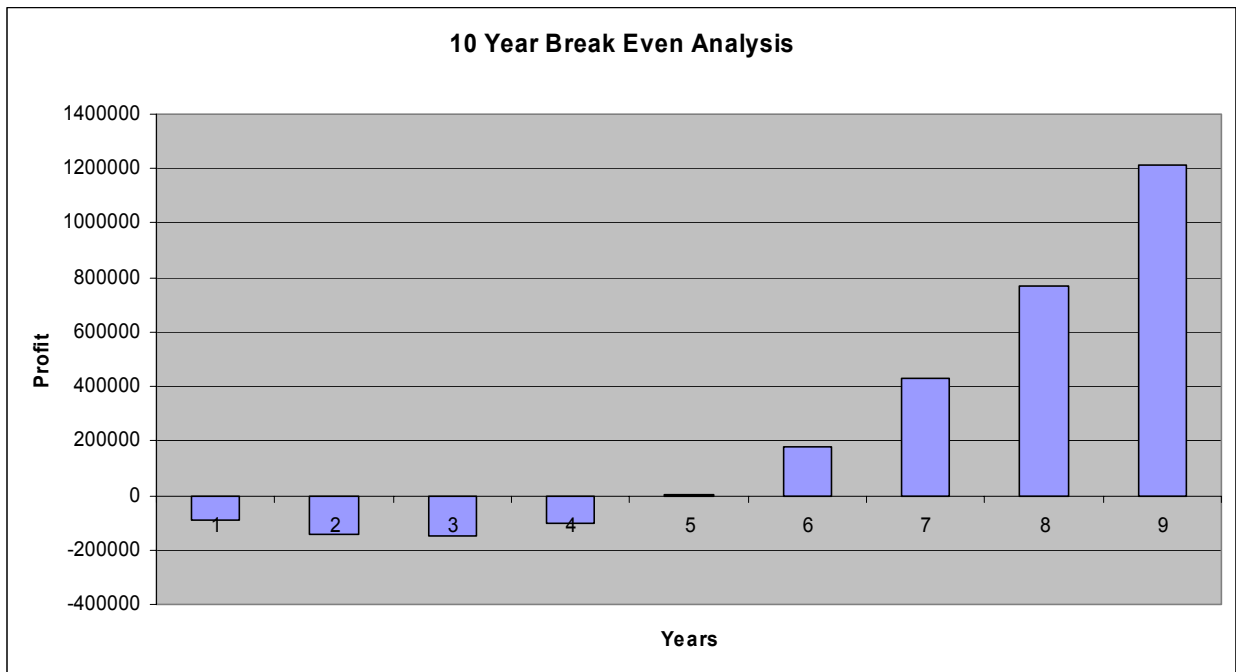
An increase in success rates in mathematics and a possibility for lower attrition rates.

Price point

\$15,000 for one board, one microphone, and the software

Return on investment for business

With the sale of 20 systems in the first year and a 15% increase in sales every year afterwards, we can expect to break even in the fifth year. We will break even with the sale of our 27th system per year.



Competition Matrix

	Does not require use of camera(s)	Does not require use of LCD	Does not require a full time operator	Does not require a change in teaching style	Records audio	Records visual	Scalable visual output
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Student Audio Visual e-Tool	x	x	x	x	x	x	x
SmartBoard	x		x	x	x	x	
Mimio	x	x	x	x		x	
Quartet IdeaShare Board	x	x	x	x		x	
Video camera/Teletechnet		x			x	x	

There are several competing technologies, but each one has some detriments and/or missing components that our solution addresses.

Advertising

We can use direct marketing to university/college mathematics departments and consortiums.

Account representatives can attend several conferences aimed at teaching mathematics such as the following:

International Conference on Technology in Collegiate Mathematics

<http://www.aw-bc.com/ictcm/index.shtml>

National Council of Teachers of Mathematics

<http://www.nctm.org/meetings/>

Mathematics Association of America

<http://www.maa.org/>

American Mathematical Association of Two-Year Colleges

<http://www.amatyc.org/>

Funding

With a focus on adding technology that aims at increasing scholastic performance, SAVE will be the conduit to bring technology into the classroom. Key to success of this goal is the choice for the financier, and the National Science Foundation's Small Business Innovative Research Program seeks to fund the development of innovative ideas such as ours for small businesses.

Success in Phase I, extending through the Spring semester of 2005 (1/17/05 through 6/10/05), will mostly require funding for salaries dedicated to research, prototype

planning, programming, Management, and third party product reviews, will require \$100,000 in grant funding by our chosen funding agency. Employees will include a Project Manager, 3 Hardware Developers, 3 Software Developers, and 2 expert consultants: an Educational Consultant and a Technical Consultant. Forty percent of the total funded sum will be allotted for overhead, which will be dedicated to personal salaries.

Phase II requires 2 years of intense development, and demands a much larger backing of financial support than Phase I. Here, development and refining are the primary concerns. Lasting a full 2 years (6/10/05 through 6/11/05), it is split into major programming and test stages - Alpha/Beta Development & Testing and Final Development & Field Trials. The most financially demanding part of phase 2 will be the employment of a Project Manager, Software Developers, Hardware Developers, Web Developer, Testing Programmers, a Technical Staff (3), and the 2 Consultants. Also involved in the budget is the hardware (Development Server, Desktops (14), Whiteboard (3), & Microphone (3)) and software (Flash (2), Microsoft Visual C# .NET (7), Photoshop CS or comparable photo editing program (1), and Microsoft Office (14)) and miscellaneous overhead costs. The target sum for funding for the above items is \$750,000.

As Phase II ends, the National Science Foundation will reward grantees by attempting to unite investors with our project, providing funding and support through a grounded, proven institution that meet a high standard of requirements set by the NSF. It is important that we are aligned with Universities and Colleges, in spirit and as a funding source. Our mission is to introduce a technologically advanced solution to the modern classroom that will be unobtrusive to the teacher, while aiding the student in necessary repetition. During Phase III, it will be our aim to seek financial solidarity through demonstrations and sample lectures throughout the country in various Secondary Educational Forums. As a supplement to this, we will also be taking a lesser (but important nonetheless) focus on high schools. This will help visibility of our product and potentially will open important alternate sources of revenue. In Phase III, we break even at Year 5 of production. Before that, we incur approximately \$150,000 in debt by the end of Year 3 that will be covered by small business loans secured through the Small Business Administration and through local banks.

The most important funding decision is the use of a COTS solution for our main component - the whiteboard. This includes built-in Application Programming Interface (API) calls that will be easily interfaced with in the customized application set that we will be building for our project. The whiteboards that we have chosen have already gone through rigorous testing. All of this will inevitably lead to a savings in time, manpower, and ultimately money. Other factors that have been considered in our cost analysis are reduction of redundant software or hardware where they are unnecessary. This reduction will aid in our target of meeting financial goals in the 3rd phase. Profit and momentum are key in this phase, so even these small factors can be key to the project's success.

6. Consultants and Subawards/Subcontracts

Educational Consultant

The educational consultant is utilized in the understanding of educational methodologies that will support the development of the project. The consultant will assist in the development of a product that will positively affect student's learning ability by emphasizing repetition of step by step problems. By attaining an outside source with explicit studies involving educational methods, the hope is to clearly determine areas of teaching that can make the most of technology to improve educational practices.

During phase one of the intended grant proposal the educational consultant will be acquired as a resource in analyzing the problematic areas of study. Advice on these problematic areas will aid in the design of the product as well as suggestion and critiquing of features and components of the product.

The educational consultant will be on hand for a limited period of time during each of the four parts of phase two which is comprised of two development phases and two testing phases. The consultant will be representing the opinions of the consensus in the locations (universities, schools, etc.) that will be used during this phase. The consensus will include evaluations from teachers and students that will be presented in the way desired by the consultant (survey, poll, etc.). Being present in the classrooms during testing phases will assure accurate data and reactions for and against the product. The consultant will have sole responsibility of these forms and will provide a complete analysis of the results in a useful and understanding fashion.

Desired Educational Consultant

Richard C. Overbaugh, Ed.D.
Darden College of Education
Department of Education Curriculum & Instruction
Old Dominion University
Norfolk, VA 23529-0161
roverbau@odu.edu
<http://www.odu.edu/educ/roverbau/vita/vitae.htm> as of December 15, 2004

Mr. Overbaugh is a program coordinator and professor for instructional design and technology. He has implemented technology into the classroom and curricula in order to promote learning.

Technical Consultant

The technical consultant desired will be projected as an expert in the field of audio and visual elements. The consultant will collaborate primarily on the hardware aspects of the product as well as make suggestions towards the interaction between these components and the software used to capture the data of the components. The expert

attained will have experience in developing new hardware and possibly experience in the audio or visual components suggested.

For the duration of phases one and two the technical consultant will be scheduled to provide guidance during the development sub phases of the product. The consultant will have knowledge of the latest technologies to be employed in the development and provide options in hardware alongside each advantage and disadvantage to the technology. Researching and approving the best and most cost efficient solution to the businesses hardware and software needs will be a prime responsibility of the technical consultant. Assistance in the design of the hardware's operation will relieve possible time constraints due to any lack of unspecialized operational employees of the business.

Desired Technical Consultant

Garry Musgrave
Conceptron Associates: Independent Audio-Visual Design Consultants
1195 Durant Dr.
Coquitlam, BC Canada V3B 6R3
gmusgrave@conceptron.com
http://www.conceptron.com/profile/tech_resume.html as of December 15, 2004

Mr. Musgrave is an independent audio and visual consultant with over 20 years of experience. He is a member of many authorized professional associations as well as a certified technology specialist – design (CTS-D).

7. Equivalent or Overlapping Proposals to other Federal Agencies

NONE