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EDUCATION IN THE INFORMATION AGE

CONFERENCE PROCEEDINGS

April 17-19, 1996

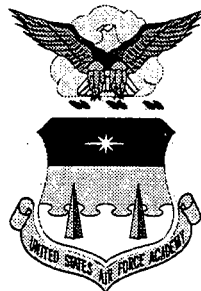
Plenary Addresses
Panel Discussions
Concurrent Sessions

Editors

Carl Pletsch, PhD, USAF
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USAFA Directorate of Education

AUGUST 1997

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13. ABSTRACT (Maximum 200 Words) This USAF Academy strategic planning conference focused on the future of learning and teaching to help shape the educational architecture of the Academy. Proceedings summarize discussions between faculty and colleagues from other service academies, civilian colleges and universities, and industry. Eight plenary addresses, four working groups, and 14 concurrent sessions (workshops) are summarized. Highlights include the keynote address by the Honorable Sheila E. Widnall, Secretary of the Air Force and the USAFA Outstanding Educator Award Ceremony address by playwright, performer, and educator Len Barron. Proceedings represent the current thinking of a number of well-placed individuals attempting to anticipate the future, both of higher education and of the larger world in which service academy, college, and university graduates will have to work.				
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The Conference Proceedings entitled "Education in the Information Age" is presented as a thorough treatment of the conference, worthy of publication. The United States Air Force Academy vouches for the quality of the proceedings, without necessarily endorsing the opinions and conclusions of the authors.

A handwritten signature in dark ink, appearing to read "Donald R. Erbschloe". The signature is fluid and cursive, with the first name "Donald" being the most prominent.

DONALD R. ERBSCHLOE
Director of Faculty Research

15 Aug 97

Education in the Information Age

A conference held at the
United States Air Force Academy
April 17-19, 1996

Edited by

Dr. Carl Pietsch, Visiting Professor, USAF Academy, 1995-97
Colonel Randall J. Stiles, American Council on Education Fellow, 1996-97

August, 1997

Education in the Information Age

Introduction

During April, 1996, the USAF Academy hosted a strategic planning conference with the theme of Education in the Information Age. One of a number of the Academy's strategic planning activities, the conference was intended to focus attention on the future of learning and teaching, and to help shape the educational architecture of the Academy.

A reformed model of learning is emerging in education, giving primacy to the learner rather than the teacher. Information technology is contributing to the changes in education and reshaping society at large. And in the Air Force, fundamental doctrine is changing in response to the new conditions and capabilities of the information age. The conference gave us the opportunity to discuss these changes across the faculty with colleagues from other service academies, civilian colleges and universities, and industry.

The conference also allowed us to review the work of two especially relevant Air Force strategic planning initiatives. *New World Vistas* was chartered by the Secretary of the Air Force and the Chief of Staff to be an independent, futuristic view of how the exponential rate of technological change will shape the 21st century Air Force. Led by the Air Force Scientific Advisory Board, this work produced 12 volumes describing the future. *Air Force 2025*, led by Air University, was a similar forecasting effort but broader in scope than *New World Vistas*. Results from both of these studies were presented at the conference, and the implications for the future of education were discussed.

Eight plenary addresses were delivered over the two and one half day period of the conference. The settings varied from the keynote address delivered by the Honorable Sheila E. Widnall, Secretary of the Air Force, to the Outstanding Educator Award Ceremony address delivered by playwright, performer, and educator Len Barron, and included early morning, after dinner, and lunch speeches. Transcripts of all these addresses are included in this volume; they have been lightly edited for this publication. These papers represent the current thinking of a number of well-placed individuals attempting to anticipate the future, both of higher education and of the larger world in which college, university, and service academy graduates will have to work.

Also included in this publication are summaries of the discussion of four working groups which met during the conference. These groups focused on the following four issues: 1) the changing contexts for education, 2) the future of universities and service academies as organizations, 3) learner-centered education, and 4) teaching methods in an era of advancing technologies.

It is our hope that the ideas contained in this publication will serve as an aid to those who are creating the future of education at the Air Force Academy. In our pursuit of excellence, we must not only think about how to improve our existing practices and procedures, but also how we might accomplish our mission differently in the 21st century.

Acknowledgments

In addition to those speakers and panel leaders named in this volume who contributed their ideas to the conference, many others were instrumental in its success. We are indeed grateful to Lieutenant General Paul Stein and Brigadier General Ruben Cubero for their support of this ambitious project. Lieutenant Colonel Jill Crotty, Lieutenant Colonel Larry Strawser, Dr. Mary Marlino, and Dr. Dean Wilson served as members of the planning team from beginning to end. Lieutenant Colonel Milt Nielsen organized exhibits and demonstrations of the use of educational technology at the Air Force Academy. Lieutenant Colonels Pete Heinz and Chuck Wood, Majors Ross Duber, Gwen Hall, and Greg Elder, and Dr. Jeanne Smith led the groups who handled all the logistics issues. Nearly every member of the Academy's Faculty Forum and many members of the Junior Faculty Council made important contributions during the conference. Captain Jay Rothhaupt has led the effort to bring these printed proceedings to closure. And finally, we want to thank the hundreds of participants who contributed their time, energy and thoughts about the future of education at the Air Force Academy.

Randall J. Stiles, Colonel, USAF
Director of Education

Carl Pletsch, PhD
Visiting Professor

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The Future Air Force: Predictions and Projections

The Honorable Sheila E. Widnall

Education in the Information Age Conference

April 17-19, 1996

United States Air Force Academy, Colorado

As Eve said to Adam when they left the Garden of Eden, "We live in times of great change." And so through the ages, each successive generation feels the tug of change--often longing for the old and familiar. But each generation also has its visionaries, its idealists--ready to step forward and seize the day.

Like all innovations since the dawn of time, the ongoing revolution in information technology has been greeted by some with skepticism--by some with denial--by some who welcome the changes it brings, and look for ways to turn it to their advantage. Whatever your view, one thing is certain: there is no turning back. Once a scientific breakthrough is released into the world, it cannot be taken back. So today's innovations--sprouting like plants from earlier technologies--are here to stay. And today we see two separate revolutions, playing on each other and multiplying each other's effects--one in information technologies, the other in communications.

In fact, the rise of information technologies has transformed economic and social life in ways that hardly need elaboration--except that it's fun to do so. Already, the information technology and communications sector of our economy has grown to 10 percent of our gross domestic product. More Americans make computers than cars, more build semiconductors than construction machinery. Information technology is penetrating every sector of our lives in ways that are stunning. Just think of the changes brought by the computer, the transistor, the laser, the fax. Each time you toss out a "singing" greeting card, you are disposing of more computing power than existed in the entire world before 1950. And if you buy a new car this year, you'll find more computer power under the hood than Neil Armstrong had in his lunar lander.

In today's age of networked intelligence, silicon, microprocessors, and roads of glass fiber as thin as a human hair are allowing people across the hall and across the planet to communicate with each other. And in keeping with the "law of unintended consequences," we see that these advances, fielded for strictly technical and economic reasons, are fueling profound changes in every sphere of human activity. Whole nations have moved toward democracy under the pressure of these technologies; national economies are being restructured; the social fabric of nations around the world has been rewoven as people get a wider view of the world around them.

But we're here today with a less ambitious agenda--we just have to talk about the effects of these technologies on the Air Force--and on the Academy.

Well, first off--to set the parameters for this discussion--we are in the midst of a revolution in the Air Force. To outward appearances things are relatively calm. It's a period of relative stability as we near the end of our decade-long drawdown. But this is a time of historic, fundamental change for our institution. Advances in information and communications technology are at the heart of these changes.

Just look back thirty years at the Air Force--engaged, at that time, in the war in Southeast Asia. The one constant between our operations then and now is the skill and bravery of our people. Just about everything else has changed--often in ways invisible to the naked eye.

Tools

As you look back on that conflict, there was a striking divergence in the technical development of the tools of our trade. We had wonderful aircraft--the F-105, the F-4. But our command and control infrastructure and our intelligence both lagged--and in some fundamental ways, our adversary was able to get inside our decision loop.

Contrast that with our more recent conflicts--Desert Storm and Deliberate Force. We had some overpowering advantages in those engagements--from the intelligence on our adversaries, to the battlefield awareness that gave our commanders an incredible advantage, to the communications capability that yielded unmatched flexibility, to the navigation systems that provided a degree of precision to our forces that was inconceivable thirty years ago. We enjoyed these advantages precisely because we had made a decade-long effort to push the state of the art in information technologies, and embed these intelligently in our forces.

Last month I took a trip to Bosnia and Italy because I wanted to see all this for myself. At Vicenza I visited the command center where General Mike Ryan directs the very complex, multinational air operation taking place in the Balkans. I saw the systems that we use to display the air picture, both friendly and enemy, in real-time. I saw the intelligence cell in a room adjoining his command center. I saw information dominance in action. I watched our commanders seeing the action as it happened, retasking our forces to get the mission done, and retasking our intel assets to get the right picture as the action unfolded. I saw us gather data and distribute it in minutes throughout the NATO chain of command--a process that only a few years ago would have taken weeks, not minutes.

All of that technology, in the end, was there to give the battle commander the picture he needs to make the right decision and the connectivity he needs to get that decision carried out in accordance with his vision.

In years past we have spent billions on making sure our lethal technology would work. We built the best aircraft on earth--witness the F-15, with its unmatched aerodynamics, its avionics and its weaponry. This latest generation in command and

control, though, helps the battle commander get the right number of F-15s to the right place at the right time. We are making the investment in the human dimension to create the same sort of superiority that we have long enjoyed in our equipment.

Nor is this investment focused solely on our commanders. During my visit to Aviano I talked with some of the pilots who had participated in Deliberate Force last summer. They demonstrated the Powerscene system that had formed such an important part of their capabilities during that remarkable air campaign. These pilots, assigned a mission tasking, had the capability to sit in a room at the back of the wing headquarters at Aviano, and practice flying the mission on a simulator that visually displayed the Bosnian terrain they would be operating over to a resolution of one meter.

These pilots could practice their missions--get comfortable with the visual landmarks in the target area--try different tactics and approaches and in doing so, eliminate some of the nasty surprises that are a fundamental feature of combat. They marveled at the realism of that simulator--how they got so involved in the mission there, firmly on terra firma, that they finished the training period tired and with sweaty palms. They all came away from this experience with a keen understanding of that old adage--"the more you sweat in peace, the less you bleed in war."

Warfare

Certainly that technology is impressive. But its strategic impact was even more so. That air operation last summer was militarily robust--but it was politically fragile. At the first report of civilian casualties or collateral damage, that entire operation would have been at serious risk. The mission preparation that our new information technology enabled us to employ was, in large part, responsible for the fact that the report of civilian casualties never came--and we were able to press the campaign through to completion. A lot of things had to go right for our air operation to create the conditions for the peace which has now settled over that land. Our Powerscene technology played a major role in ensuring that they did exactly that.

At Aviano and Vicenza I saw the leading edge of today's art of the possible. A week earlier, I had seen the future. I caught a glimpse of the next generation and the possibilities that lie before us--to be seized if we have the vision and the energy.

I hosted the other Service Secretaries in a conference focusing on modeling and simulation. We flew down to the Joint Training and Simulation Center at USACOM, near Langley. We toured the facilities they have established there, just over the past few months. They have built a battle lab for training our joint force commanders and their staffs--so that future Mike Ryans will have had a chance to explore their options, see the logical consequences of their decisions, and get a look at how an intelligent adversary might respond to various decisions.

At that command center we can conduct an exercise integrating real decision-makers working against a simulated enemy force--and real aircraft flown on training ranges thousands of miles away against simulated adversaries--using modeled weaponry so we can get a look at how these new weapons will affect our capabilities. From that command center, as we exercise, we can command an Aegis cruiser in the Mediterranean, or a Patriot battery in Korea, or an AWACS in Southwest Asia, or if we wish, all at the same time.

We have just begun to work with these capabilities, and to understand their potential. One thing I can confidently predict, though, is that the potential we *don't* yet see will be at least as important as the payoffs we realize today. The law of unintended consequences is alive and well.

Long Range Planning

Far though we have come, as we look toward the future and the opportunities before us, the image that comes to mind is of standing before an open doorway, looking through it toward endless possibilities beyond. So now we're doing what we can to create our future, to use our knowledge today to imagine where we might go tomorrow.

Any strategic planner can tell you that if you don't know where you are going, any road will get you there. If you want to get where you want to go, though, you have to begin by laying out a path to the future. In short, you have to plan.

Over the past months, the Air Force has been involved in a number of planning efforts, and has established a long-range planning group under General John Gordon to integrate them all. By the way, I was pleased to hear that the Academy was involved in both *New World Vistas* and *Air Force 2025*. These studies have forced us to face our changing environment in a systematic and broad-based way, with the major commands and the headquarters working to find a coherent, clear course. Our intent is not just to paint a picture of the future, interesting though such a picture might be, but to lay out the paths toward the most promising capabilities, and to then build this long-range planning focus into the staff on a permanent basis.

One effort in which I'm particularly excited is the latest study by the Scientific Advisory Board: *New World Vistas*. As most of you know, General Fogleman and I asked the SAB to look at the technical possibilities opening over the next fifty years. The objective was to repeat Theodore von Karman's *Toward New Horizons* study of 1946. That study, conducted during an era of propeller-driven fighters and massed bomber raids, predicted many of our current capabilities, such as supersonic aircraft, pilotless aircraft, GPS, precision guided munitions, and weather satellites.

Now its time to extend our horizons once again. New *World Vistas* gives us inspiring possibilities; such as:

- hypersonic stealthy transport aircraft
- expanded uses for UAVs, including combat missions
- GPS with 1 centimeter accuracy, and
- continuous worldwide hyperspectral observations with 5-10 meter accuracy using small distributed satellites--again, building the information dominance that will be so central to warfare in the years to come.

There's no real reason to expect that all of these ideas will come to fruition. We all know that prediction is difficult, especially with regard to the future... But in the aggregate, these ideas point our way further down the path we have started--to the potential that is there.

Long range planning--a serious look at the future--is important to any organization that wants to remain relevant, engaged, growing, and improving. No one--no business, no educational institution, no employee, no instructor--can afford to remain static and stable. We must constantly gauge the environment--new problems, new technologies, new requirements--if we want to stay fresh and productive. I have seen this in education, in industry, in the Air Force, and I know it applies to you too.

Just before I left MIT, I took part in a long range plan for the School of Engineering. We conducted an in-depth study of the requirements and objectives for aerospace education over the next 20 years. Our resulting strategic plan for the department made some substantial changes in the curriculum and in the entire program, based on our vision and objectives for undergraduate education. We looked at the future practices of aerospace engineering and designed a program to prepare our students for a career in any sector of the industry.

Officer Education

And that leads us to what we do here at the Air Force Academy to prepare our future officers for a career in the Air Force. I like to think of Fairchild Hall as a giant building with four walls and the future inside. How are we shaping that future?

Well, the Academy has an unparalleled record of assimilating new educational technology. I expect that record to continue. Certainly if this conference is any indication, the leadership here has a clear view of the way ahead. I would offer some cautions, though, as you set about the task ahead of you.

First, entrancing though these new technologies are, they are not the product. The product is the lieutenants you send to join the Air Force each summer.

Second, there is no such thing as a free lunch. In education, as in any endeavor, progress has a price and poses its own risks.

As a first order of business, we need to ensure that all our officers are competent and comfortable with these new technologies. The information age has altered tools of the trade for all our career paths. Intelligence officers will use digitized transfer systems. Information and communications officers will link LANs to other webs of communications systems. Even our history major must know how to run a desk top data base. The Academies, since West Point first opened several millennia ago, have always had a strong technical component. We must ensure that we turn out officers who are comfortable with this new technology that will play such an enormous role in the force they will someday lead.

Incorporating these technologies in your day-to-day instruction will take careful thought. A number of advantages come to mind. In many cases, you can put courses on a disk, allowing students to proceed at their own pace, unhampered by 19 other classmates competing for the instructor's attention. Another obvious advantage is the increased access to information, which decreases the time used to gather data, and increases the variety of sources and ideas. The sorts of distributed simulation and modeling that I spoke of earlier have obvious potential here. Over time I expect these technologies to fundamentally alter the educational experience here as elsewhere.

But we can't regard these innovations as panaceas. Many students aren't stimulated enough by words on a screen. Computers cannot replace the animation of the classroom, with ideas flying through the air, taking on lives of their own and spawning new thoughts and discussion. Computers can't replace instructors--their ability to analyze every aspect of a question--to discuss the implications of various answers, and to relate these issues to the Air Force that their students will soon enter. They can't replace the lively discussion that is at the heart of the educational experience.

And we must resist the temptation to view any high-tech, multimedia presentation as the key to reaching our students. As with 36mm slides, as with books, as with clay tablets marked by a stylus, garbage in yields garbage out. Visually dazzling garbage is still garbage. It all goes back to understanding that the product is still the student's growth and not the technology that feeds that growth.

Think of how the visual aspects of television have blurred the line between news and entertainment. How much of the bandwidth available today on TV is devoted to anything that would remotely fall within Shannon's definition of information? The danger for education is obvious: students becoming passive receivers rather than active processors.

And in the area of research, new concerns arise. First we need to ensure that our students grow the judgment to filter and understand what they find. Information on the net hasn't always passed the scrutiny and review we've come to expect of written works.

In fact, it's rather the opposite--there are a lot of people putting out "information" on the net that is unfettered by either fact, or judgment.

I don't consider that an impassable hurdle--it's all part of the marketplace of ideas. But it does pose a challenge for the faculty here. With nearly unlimited information, students may find it tempting to go data-mining, basing their judgments on a hazy vision of reality, finding plenty of data to back it up, without the independent judgment or background to assess this information that is so freely available. It's easier to go astray. We must help students learn to avoid the pitfalls inherent in this new arena of information saturation.

Second, with easier access to information, we should demand more of our students in the processing and analysis of that information. To ensure critical thinking, we must expect much more than simple regurgitation. Our students must learn to build their own patterns, to paint their own pictures of the world based on what they find.

I've heard an amusing story about a cultural train wreck waiting around the bend in academia. That is, when the generation of teenage Internet users hits the universities--where the average age of a tenured professor is fifty--some predict that sparks will fly and communication will grind to a halt.

It's an entertaining prospect, although I can't conceive of that happening here. You have too many people anticipating the future, and you're blessed with a constant flow of fresh ideas from the field. You have a reputation of continually expanding your capacities. Keep it up. In the end, it's the instructor who brings experience, vision, and the human capacity for life-long learning that will influence our future officers.

What we've been talking about is a vast array of new capabilities for handling information and processing it to form sound judgments. But to be useful to future Air Force officers these capabilities must rest on the base provided by the core values of officership: integrity, service before self, and excellence. These new capabilities will be meaningless unless officers use them to fulfill their fundamental responsibilities as leaders at every level. In the end the success of the Air Force comes down to its people using their considerable skills with dedication to the mission and service to this nation. Individual virtuosity in service of personal agendas is not our goal.

So that's my thumbnail sketch of how information technology is changing the Air Force: from our tools, to our missions, to the training of our leaders. We have the opportunity--in fact, we have the obligation--to be active participants in the change, to imagine where we're going and help guide others toward the habits of constant improvement that will keep us relevant.

In closing, I'd like to commend the Air Force Academy for hosting this conference at this critical juncture. With two major long-range studies just completed,

and the class of 2000 arriving in just two months, this is a perfect opportunity to survey where we are and where we're going.

The future doesn't just happen. It's created by people with values, aspirations, and growing expectations. It's created by those who demand that the smaller, more open world we live in must be a better one. Good luck in your efforts throughout this conference to liberate your insights and meet that future with confidence and optimism.

Learning Leadership in Permanent White-Water

Dr. Peter B. Vaill

Education in the Information Age Conference

April 17-19, 1996

United States Air Force Academy, Colorado

Thank you very much, it's really a pleasure to be here. I have no connection to Vail. My father did a lot of genealogical research, and he found out that the family landed on Long Island. The smart ones went west to New Jersey, the dumb ones went across the Sound and became Yankee rock farmers. I'm from the dumb half of the family that never left New England until late in the 19th century while the others were out here getting rich.

In any event, it's nice to be back and have a chance to visit Colorado Springs again. This is the first time I've been at the Air Force Academy, and I want to thank all of the wonderful hosting and hostessing that you've all done. I want to recognize, in particular, Major Gwen Hall and Major Rick Abderhalden who have been squiring me around and talking back and forth on the long distance phone and fax machine to arrange this event. I'm very grateful, and it's been a wonderful visit up to now.

With dinner speeches there's a triple-whammy problem. Number one, we're all in the grip of postprandial narcosis. I learned that phrase during management training I did with some nurses. It simply means your stomach is sucking blood from your brain at this point like crazy, and we well know the consequences of loss of blood to the brain.

As an academic audience, I know you'll all appreciate the second whammy--even if you don't agree with me. A wonderful definition of a professor is someone who talks in someone else's sleep. So that's the second whammy.

The third whammy, so I've been told, is that my style on a platform reminds people of Bob Newhart--kind of laid back and casual. Actually, I think Bob Newhart is a little strident and abrasive myself. So for this triple whammy, I'll do my best to keep you awake. If you get totally bored, there is a page on your table with words and phrases which may prompt you to reminisce about some adventures from your life.

I would like to call your attention to the statement on the awards program that I was one of the top ten Organizational Development specialists in 1985. As the folks in the management department would say, anything from 1985 is now fully depreciated. But in any event, that top ten is a kind of good news/bad news joke. It's nice to be elected to the top ten of anything. But in that particular case, the research method used to determine the top ten is the one that I spent all my time as a professor criticizing. So as I say, it's a good news/bad news joke. With reference to the assessment theme of our conference--I'm confident that the assessment methods by which tonight's outstanding

educators were determined is a sound research method, and that they can take pleasure in their achievement with little system noise.

In any event, let me move right into the main thrust of my comments, because we are all tired, and we do have postprandial narcosis. I don't know if you've had a chance to glance at this legal-sized sheet that should have been distributed to all the tables; but for me, it's a simple, convenient way to begin talking about the pace of change and the kind of change that we're all absorbing and facing and dealing with all the time. [Ed. note: The legal-sized sheet listed approximately 700 technology words and phrases with no readily apparent commonality.]

As you can see, the heading is What Do All These Words and Phrases Have In Common? I was just saying to my dinner partner that I can make a three-credit course out of this topic. But I don't think you would like me to; so I'll tell you the answer to move things along here. By the way, there is a smart aleck second-year doctoral student answer, which is "They're all typed on the same word processor," but that is not the right answer.

The right answer is that none of these words and phrases existed in the public mind nor had any real meaning in the public mind before 1970. So this is an interesting snapshot of technologies. Did anybody guess "around 1970," by the way? A few of you. Some of these words and phrases, particularly the medical diseases and some of the military terms, had meaning within professional subcultures. But as far as being something you can see on the news or read on the front page of the newspaper, most of them were invisible to the general public.

Now they are used casually without even being defined and described. Everybody knows what the Laffer curve and what mad cow disease are, and so forth and so on. In effect, what we are all doing as citizens and as professionals is kind of engaged in a nonstop process of osmosing these incredible gradients and kinds of change that our society, perhaps unique in history, has been producing over the last 150 or 200 years.

So I like to use this page as a reminder of the context in which we're talking. We're talking as a society and a group of educated people who have been living at a faster pace and with a steeper change gradient than quite possibly has ever been experienced before in human history. And the beat goes on. There doesn't seem to be any likelihood that any of this is going to let up in the near future.

The other thing interesting about this page is that most of these words and phrases are things we hear about in a kind of passive mode as a citizen. However, if you're any kind of senior executive of an organization, you can't settle for what Dan Rather or *Time* magazine tells you about their meaning or significance. Instead, you put somebody to work do a white paper and briefing for you. For many senior executive jobs, lacking detailed knowledge of 200-300 of these words and phrases might leave your strategic thinking impoverished, leave your organization in peril, or leave you missing significant

thinking impoverished, leave your organization in peril, or leave you missing significant market opportunities.

So when we talk casually about "keeping up," we are talking about a nonstop, high-energy process of exploring this environment that we are all living in the middle of and trying to understand. It's in that context that we're all gathered here.

The last thing about this page, one theme which I will return to this evening, is if you finished college or professional school after 1970, there were few who could define these words and phrases. You were pretty much on your own to attend workshops and conferences, read books, and so forth. However, since you understand what these words and phrases mean to a certain extent, you have been engaging in a process of continuous self-directed learning. Whether you deliberately recognize it or call it self-directed learning, that's what we've all been doing and it is the reality of the world that we live in. If we cannot conduct a continuous process of very efficient and effective self-directed learning, we're going to be very much--as you folks like to say--behind the power curve.

Indeed, as many of us grow older, we begin to feel a cold wind of obsolescence on the back of our necks as we realize that a whole technology, industry, or group of problems has suddenly blossomed in society, and we haven't kept up with it and aren't too sure what it's all about. I'm still on WordPerfect myself, and I've got to get cracking on Windows and Windows 95 if I'm not going to have that problem happen to me.

I have taken this phenomenon of the amount of change we're dealing with and have crystallized it in a phrase that I call "permanent white-water": that feeling of unanticipated and unprecedented continuous change, continuous surprise, and continuous challenge of novel problems.

Today Secretary Widnall talked about the law of unintended consequences. I want to take that one step further and talk about, if there is such a thing, a law of inconceivable consequences. These consequences are things to which all of our algorithms, frameworks, and models could not alert us. For example, I have direct personal knowledge that the Exxon Valdez oil spill was beyond the comprehension of anybody in Exxon, despite the fact that they have rooms full of contingency plans for what to do about oil spills. Herman Kahn even wrote a book on thermonuclear war in the '50s or '60s, called "Thinking About the Unthinkable." Fortunately, we don't have to have thermonuclear war to know we are in the midst of the unthinkable on a many different fronts. That's why this idea of permanent white-water and the law of inconceivable, perhaps unimaginable consequences, is relevant.

Again, we can read of these changes in the newspaper, but it's much more important to try to consider the men and women who deal with the problems; the project manager for dealing with the Exxon Valdez problem; the person that Cobra golf clubs has put on the Greg Norman advertising account [Ed. note: Professional golfer Greg Norman lost a significant lead on the last day of a recent tournament.] Believe me, Greg Norman

is a multi-million-dollar problem for Cobra now. Cobra is probably engaged in big-time damage control because the worldwide TV cameras kept zeroing in on this club head which was about to hit the ball on Sunday afternoon. That club head was hitting the ball far right or far left or into the water in one of the most prestigious golf tournaments in the world. What you do when Magic Johnson suddenly is unable to play basketball or Michael Jordan decides he's going to retire?

What you do if you're the chief of the graphics department of Sports Illustrated? This year's NCAA championships just finished, but two years ago, when Arkansas won, Sports Illustrated had this wonderful idea that they would put together a special edition. The edition would have lots and lots of advertising, of course, and they would market it throughout the South and the Southeast to celebrate the Arkansas basketball team.

This issue of Sports Illustrated had a centerfold of the Arkansas basketball team at the moment of victory, delirious with joy; tears, balloons, crowds, hugs, rolling on the floor, all that stuff. Only one problem, it wasn't the Arkansas basketball team, it was the Alabama team from two weeks earlier in the tournament. You and I chuckle, but don't you realize you're laughing at some poor son-of-a-gun in the Sports Illustrated graphics department who's having a Maalox moment when he discovers he's now got to do damage control.

With the Academy's interest in leadership, I'll relate one of my favorite white-water situations about the story of the alumnus who walked into the University of Richmond and said, "I think this university should do more about leadership, and I want to give you \$20 million for you to get started." The faculty of the University of Richmond decided to deliberate for a year before deciding they even wanted to accept the \$20 million gift. As Dean of the Faculty, General Cubero will appreciate that joke.

I mean simply that digesting \$20 million into meaningful leadership education is a white-water problem of the first order, for which there is no precedent, you've got to make it up as you go along. Colonel Stiles was talking about the emphasis that you place here in the Academy on helping the cadets to deal with unstructured problems. That \$20 million gift is one of these completely unstructured white-water problems.

A very tragic medical problem occurred in Portland about three years ago when a heart transplant team put the wrong heart in a guy's body. Some of you may have heard that on the news. They opened him up, went down to the tissue bank, got the heart, put it in, stitched him up, and took him down the hall to the intensive care. Later they discovered the intended heart was still in the tissue bank.

Once again, if you're the hospital administrator; you're looking at your strategic plan or whatever, and the phone rings, and it's the operating room saying "Boss, we've got a problem." Of course, the first things you may think about are the family and the patient, probably the 5 o'clock news, what you're going to do, and maybe even about Mike Wallace of 60 Minutes coming for a visit! You may think about your accreditation

and multi-million-dollar lawsuits, and throughout all of this you're thinking about the patient, too.

Most executives all over the world must deal with this nonstop stream of white-water problems daily. The trouble is we don't observe them dealing with it, we don't have good ways of talking about it; and they don't have good ways of expressing their ability to do it; making it essentially invisible.

My phrase for all the ability to handle these kinds of problems is *white-water leadership*. I'm trying to get that phrase institutionalized, and I just wish Senator D'Amato would please shut up and sit down, because... [Ed. note: Senator D'Amato is known for his tenacious investigation during the Whitewater hearings.]

The marketing department of Jossey-Bass Publishers refused to name my book *White-Water Leadership* because they weren't sure what was going to happen to the word white-water in the next six months. I hope I can save this word so it doesn't get tied up with an unproductive meaning. Besides, I want to make some money off that word, and if it gets confounded by Washington politics, I won't be able to do that!

White-water leadership is my working phrase, but what does it take? How do we, as educators, help young men and women, as well as adults, develop the ability to handle unstructured problems? What's the educational and training dimension of this? That's what I've been developing over nearly ten years.

Another interesting white-water story is about the city of Washington, D.C.'s management problems. Mayor Berry inadvertently contributed a phrase to the world of white-water leadership that I think is worth remembering. The reporters always like to try to catch him in slips of the tongue of one sort or another. At one point he was asked at a press conference, "Mayor Berry, is the District of Columbia in fiscal chaos?" And he said, "No, it's not; it's in fiscal crisis, but it is not in fiscal chaos."

Well, that's a pretty fat leading question for any reporter with any brains, so some Sam Donaldson type stood up and said "Well, Mayor Berry, perhaps you could inform us of the difference between fiscal crisis and fiscal chaos." What Marion Berry said, which should go into the canon of principles of white-water leadership is, "A fiscal crisis is when you're losing millions of dollars a day and you know it. Fiscal chaos is when you don't."

The other half of my talk involves the other page that's on your tables called "The Learning Premise and Leaderly Learning," which I'll introduce with another dean's story for General Cubero.

This hit me between the eyes, if I may put it that way, a few months ago and transformed all of my thinking about higher education; not just management and leadership education, but all of higher education including mathematics, statistics, French, political science. It came to me through the lens or the window of observing my

three successors at George Washington University School of Business and Public Management. I resigned from the deanship in 1978 and in the succeeding 18 years, I've had three successors. All three of them were superbly qualified for the job. All three had lots and lots of executive experience in higher education, as well as in government and in industry. One of them was a retired female Air Force colonel.

All three were well-known on the faculty, widely respected, and regarded as very effective deans. All had much better resumes when they became dean than I had. All were 20 years older than I had been, with that much more experience. So it's not false modesty for me to say that all three of them were certainly as well and very probably much better qualified to do the job that I was doing.

Now here I sit on the sidelines, able to observe three different individuals doing a job that I already knew pretty well. Also, since I'm a professor of organizational research, I supposedly have some credentials to study their performance. A few months ago I concluded something about those three which revolutionized my thinking about higher education.

As many of you know, we in the field of managerial leadership just debate and debate and debate over what are the three, five, or seven key characteristics of effective leadership. Libraries are full of very, very enticing lists, very interesting and provocative statements by managerial leadership like Peter Drucker and Tom Peters. Even knowing about these characteristics and statements, I asked myself "What is the one generalization I could make about all three of these individuals?"

Overwhelmingly, the most important generalization I would make about all three of them is that the deanship for them and in retrospect, for me, was a *nonstop learning experience*. All of the résumés, executive ability, energy, wisdom, and administrative touch which they brought to the job was secondary to the another fact. That is they couldn't deal with the white-water, with the spontaneous, emergent, surprising, novel, unpredictable, inconceivable kinds of events that occurred by simply riding their resume or their stock of managerial techniques. If they didn't have a *nonstop learning experience*, they couldn't cope with the white-water and they may might go down in flames as dean.

In several cases, the learning process was an anguished and painful one, in which it was not at all clear that the school would figure out what to do in time. This includes problems with our accreditors and funding, a couple of serious enrollment drops, some student shenanigans that got everybody upset, and some extremely embarrassing faculty shenanigans; all where the dean had to do something. But there was no book, no Five Easy Principles, nothing that Peter Drucker had written that really solved the problem.

As I watched them in the white-water engaging in this nonstop learning process, I came to the conclusion called The Learning Premise. [Ed. note: The slide shown:

THE LEARNING PREMISE

In dynamic, rapidly changing situations of "permanent white water," where unprecedented challenges and crises are occurring continually, the ability to learn effectively is the primary (in)competence.

Therefore, effective managerial leadership in such situations cannot ever be sufficiently learned.

Effective managerial leadership in such situations is learning.

Peter Vaill, 1996]

I'm starting from The Learning Premise today, and I invite you all, especially educators and those interested in this conference which we're kicking off today, to think of it as a point of departure.

In these rapidly changing situations of white-water, where unprecedented challenges and crises are occurring continually, the ability to learn effectively is the primary incompetence. (I'll say more in a minute about why I say incompetence.) Therefore, the main thing to say about managerial leadership is that it is not learned, it is learning.

Ask yourself to what extent your cadets graduate knowing that military leadership is learning. Knowing they are just at the bottom of the learning curve that will continue for the rest of their lives. Knowing for all the blood, sweat and tears of the four years they've spent here that all they've done has hardly scratched the surface of the learning in their future, whether they stay in the military or go elsewhere.

Are we making that point? Are we getting that idea across? My feeling is, in general, we're not. Instead, we are leaving the students with a false sense of security that having written the term paper, read the books, performed the exercise effectively, done the simulation, and completed the internship that they now have "got it." Particularly when we put a nice, big, fat "A" grade on their transcript and give them an award or a scholarship, we lead them to think that there's this stock of ideas that you attain at school and then you go somewhere and apply them.

In today's world of permanent white-water and into the future, that model is increasingly and dangerously misleading (even if it was ever accurate). We need to tell cadets that after graduation, their learning responsibilities and opportunities will only intensify. Graduation day is the first day of unlearning the things they think they know, because Pete Vaill's legal-sized sheet will just keep spinning along with new things to learn and old things to let go of and revise and modify. If they don't understand that and we are not succeeding in communicating that to them, I don't think we're doing our students a service for the world of the future. I'm increasingly unhappy with myself and

all of us in higher education for this. This is despite what we say about the mission of our institutions, including your great Air Force Academy mission statement which I approve of completely.

I suggest to all institutions of higher education who purport to produce competent performers, that our real mission is to produce effective learners. Maybe I've had my head in the sand, but I don't think I've ever heard anybody say that quite that flatly in more than 30 years in higher education. More often, the mission stated is to produce knowledgeable people or to produce graduates or alumni or alumnae, as opposed to producing young men and women who are qualified to begin the next process.

The question is "What does it mean to be qualified to begin a process of lifelong learning?" That's the challenge I offer to this conference and in your curriculum. How is our educational effort with our students helping them experience the learning problems of a particular subject?

Now I turn your attention to seven kinds of "Leaderly Learning"; the learning in which leaders need to engage during permanent white-water. As I said a while ago, there are lots of lists about what leaders need to know. These seven items are kinds of learning that might help an individual to smooth out the white-water, to experience it in less overwhelming terms and to help others to experience it less overwhelmingly.

For example, the first one, *becoming non-disempowering*; is an extremely awkward word, a jaw breaker, kind of a grammatical impropriety. The point is, with all this talk about empowerment, we need to remind leaders to stop doing the many things that disempower their people. They need to stop blocking creativity and decision-making authority and to stop belittling and demeaning people. That disempowering behavior leaves people alienated, ineffective, dissatisfied, rebellious and so forth.

As inheritors of a one-thousand-year-old elitist system, we educators are enormously disempowering of our students. In conferences like this one, as well as in other activities here at the Air Force Academy, I interpret a lot of that. When we talk about being learner centered, we're trying to understand how we disempower our students and how to stop doing it so our students' natural energies, natural creativity, natural optimism, natural ambition can flower more fully and more freely both while they're here and, more importantly, after they leave and begin their careers.

So non-disempowering is one of the principal things if you want a leader to be effective in a white-water situation. I'll say more about that in a minute, but let me say two or three sentences about each of these other kinds of Leaderly Learning.

Developing and Discovering Teams. Developing teams is a common, important thing that leaders need to do. However, seeing groups of unconnected people who need to be connected, and helping them to find each other and build a sense of community is an even more important skill in this extremely disconnected, fast-moving white-water

world. So when I visit Bell Atlantic, MCI, or any high-tech companies, I see a need for teams where people don't even realize that option. So *discovering teams* is a terribly important kind of Leaderly Learning.

This conference is an example of the third kind of Leaderly Learning, stepping back and trying to get *the big picture* by looking at the white-water from a distance. Meg Wheatley, in her book, *Leadership and the New Science*, talks about how the best way to deal with chaos is to step back from it in time and in space; so it's very applicable to white-water problems.

Of course, strategic planners know *the big picture* idea well, but it's just as important for somebody majoring in a foreign language, in a basic science, in political science or any of the other liberal arts or engineering subjects to seek the appropriate perspective as it is for students who are majoring in strategy.

We hear the phrase 'You've got to learn to *think outside the box*' everywhere. But what is the behavior that goes with that phrase? Determining that behavior and teaching it is a learning challenge which nobody really knows how to do. Inspirational men and women teach people to think differently, but they tend to be one-of-a-kind teachers rather than teachers that have been molded to develop students who *think outside the box*. What we need is a whole industry of learning methodologies for *thinking outside the box*, so that's why it's on my Leaderly Learning list.

Murphy's Law is whatever can go wrong will go wrong. To keep things from going wrong, Murphy hauls two briefcases home, works all day on Saturdays, comes home and falls into bed most days, doesn't have time for the kids, and isn't eating well. Murphy even has a car fax machine. Murphy's trying to get more efficient, goes to Evelyn Wood, yet still gets beaten to death over whatever can go wrong.

Murphy's spouse is getting concerned about Murphy. So Murphy's spouse's law is 'Murphy's got to *lighten up*.' Murphy needs a more balanced perspective. I don't think I need to tell this group that workaholicism is a very serious problem in the military services. Although *lightening up* is important, there is very, very little educational information technology available for learning to become more cheerful. I think psychiatrists will tell us that getting people out of depression is a most difficult clinical challenge, so learning to *lighten up* is a very important kind of Leaderly Learning.

I wrote an article called *Executive Development is Spiritual Development*. It just occurred to me that if we're going to ask a leader to be inspirational for others, how is the leader inspired? What springs of creativity and hope and faith and energy does that leader draw on? Learning how to *renew one's own spirit* is also an important kind of Leaderly Learning.

American culture seems to believe individuals learn about spirituality and religion by age 21 and then maintain those beliefs thereafter. Of course the trouble is millions and

millions and millions of people don't, and lose their faith. In fact, all the great religious traditions have treated a program of spiritual development and growth as the important process; that one just keeps growing and deepening and enriching religious understanding. That's why *renewing one's spirit* is a very important kind of Leaderly Learning.

Finally, since the white-water keeps throwing us back into a state of being a beginner, we all need to learn more about being a beginner. Also, our culture is hard on beginners, claiming they're wet behind the ears, new kids on the block, and rookies. Beginners wander around in a daze, have to have their noses wiped and their hands held, and don't know what they're doing. Beginners must get out of the beginner state and into a state of mastery or competency as fast as possible. The only problem is that white-water keeps kicking you back into a beginner's state. When I move from Windows 3.1 to Windows 95, there reportedly isn't too much carryover. So if I can't be comfortable as a beginner, be willing to ask some dumb questions, and pay attention to myself as a learner, I'm not going to get very far. The same thing happens with lots of our other projects.

Unfortunately, I don't know how to *learn to be a good beginner*. I just know that there are better and worse ways to be a beginner. For example, you don't have to feel like a dumb klutz or the low person on the totem pole and so forth. Instead, there should be the possibility of joy, excitement and discovery in beginning. So learning to be a good beginner is an important learning process in the world of white-water.

I've made up a concept I call Satchmo's Paradox that describes this difficulty about learning to be a good beginner. According to Bartlett's, when someone asked Louis Armstrong "What is jazz?" Louis really did say, "If you don't know what jazz is, you'll never know." Satchmo's Paradox is when even an expert can't tell you how what you need to know or need to do. Nonetheless, people learn about lots of phenomena like jazz which don't lend themselves to didactic academic explanations like crafted paragraphs and overhead lists. So the process of becoming an effective beginner must overcome Satchmo's Paradox if we're going to keep up, thrive and enjoy the white-water environment.

By the way, I don't want to be a gloom and doom guy. Even though sometimes awfully heavy, vexing, frustrating and, indeed, scary, I really think that white-water challenges have the main virtue of placing all of us in a position of continual renewal. We couldn't ask for more opportunity to increase our own creativity, wisdom, insight, and depth as human beings than we have in this society today. To me, that is the fundamental meaning of the permanent white-water--not the fact that it's vexing and presents us with a continuing stream of Maalox moments.

I'd like to say a lot more but since the postprandial narcosis continues, I'll finish with a couple of quotations and an amusing white-water example. I heard Steve Rhinesmith, a well-known management consultant in Washington, D.C., give a briefing about cross-cultural facilitation. He principally works with companies who are engaging

in international strategic joint ventures. Among his other remarks he said, "There is no way to get significant change to occur without letting things get significantly more out of control than you're comfortable with." Although our culture considers the manager as in control, on top of things, knowing it all, and having all of the data--the manager should let go to allow the system to heal itself and let other people solve problems and keep himself from going a little nuts.

The second quotation is about sophisticated new electronic information systems, another topic of the conference. This conference is the place to be in the next three days, if anybody wants to be on the leading edge of these applications in higher education and human development. The caution I have about this topic is of getting too far ahead of the students by developing such sophisticated plans and systems that the students don't see the important processes. If you don't keep the learning challenge available and visible, the students won't see all of the thinking and the dealing with unstructured problems that is buried in those systems. And if they don't see it, they will miss the most important message because they are going to take the lead on similar systems in a few years.

W. Edwards Deming is not really known as a touchy, feely, warm, fuzzy guy--as I understand it he mainly stands up in front of his audiences and berates them. But at one point in his book, *Out of the Crisis*, he says, "In my experience people can face almost any problem except the problems of people." So my slight caution during the conference is don't get so excited, involved and preoccupied with these systems that you forget the students who need to learn about the systems, too. Instead focus on the problems of the people who are going to be using those systems and learning from them.

This talk has punctuated and intensified what we call 'lifelong learning', which I feel doesn't often have significant meaning. To attach more meaning, I'm calling it "The Learning Premise," In particular, what are the learning challenges of your subject and to what extent are your students able to identify those challenges? They need to know them so they can comfortably, enjoyably and effectively keep learning.

Finally, my example of white-water is the Naval Academy's, which has taken a beating these days, and I'm going to give them one more, although this is a pretty benign remark which I hope will not offend the Naval Academy representatives here tonight. Today, I drew from the well-known academic journal *U.S.A. Today* the following fact which I find a wonderful example of white-water. On the commencement morning in June of 1990, the superintendent of the Naval Academy was, presumably, in his quarters getting spiffed up for the ceremony in dress whites, was thinking about the awards to be presented, and was thinking about the President's visit--all the things that would be going through one's mind under those circumstances. Unfortunately, he was informed by somebody on his staff that all 1600 diplomas had, indeed, been delivered and would be awarded this afternoon at commencement. There was only one little problem. On the diploma the word "naval" was spelled as in belly button rather than as in maritime--a Maalox moment. That kind of problem might also get you on 60 Minutes, but it would get you on the worst part of 60 minutes, the Andy Rooney part.

Challenges of a Nonlinear Future

Lieutenant General Ervin J. Rokke

Education in the Information Age Conference

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It is my pleasure to be back. As a matter of fact, as I was sitting behind the curtain reflecting on F-1, this lecture hall, it occurred to me that I probably have more time in those blue seats than most of you. My first experience in F-1 was Christmas Eve of 1958. In those days, freshman cadets were not allowed to go home during their first year. I think the Academy correctly assumed we wouldn't come back. As I recall, they marched us over here, sat us down in these chairs and let us watch the movie, *Twelve O'Clock High*. It was not one of my better Christmases; in fact, I remember a tear or two as I walked back to the room. I was very homesick.

The last time I was in this auditorium was 1986, when I, as a departing Dean of Faculty, said good-bye to a marvelous group of faculty colleagues. I think I also had a tear in my eye as I left Lecture Hall F-1 on that occasion. In any event, I promise no one is going to shed tears as a result of what I'm doing this morning.

As a point of departure, I would like to refer to the vision statement we have developed at the National Defense University: "Educating strategic leaders for today and tomorrow." First of all, I'm proud of it; but secondly, I think it relates to the academies, the colleges and the universities that are represented here this morning, as well.

In a very real sense, we're all engaged in educating strategic leaders for today and tomorrow. The problem with this task is the assumption that we know something about the future. Quite frankly, I think we know very little about the future, at least very little with precision. I've listened to a stream of four-stars going through the National Defense University during my year and a half there; and without exception, they have told us, "As you look toward the future, think out of the box." Very few of them have told us what it means to get out of that box. This morning, I'd like to give you an idea at least about how I have been trying to escape my own intellectual boxes in recent months.

First of all, the intellectual boxes that I worry about are those in which I was educated as a political scientist. For example, there's the "realist" box, a box put together by greats such as Thomas Hobbes and, more recently, Hans Morgenthau, who essentially said, "Both individuals and nation-states are propelled primarily by a thirst for power." There's another box, if you will, the "idealist" box, that suggests aspirations on the part of both individuals and nation-states might be more commendable, more favorable than power. There are also the "liberal" box, the "conservative" box, and so on.

What all these boxes share, it seems to me, is a kind of ready-made intellectual argument for positions one might take on current issues. For example, if you take a "realist" box position on what we ought to do with regard to North Korea, and you're attacked intellectually, you can retreat to that box and reach down for Hobbes or Morgenthau and find an argument to sustain your position.

The reason it's difficult to get out of those boxes is that one becomes intellectually naked. And one also, of course, runs the risk of putting out propositions that are less well-founded than what we've heard from some of the great thinkers of the past. I will acknowledge at the outset that that's probably what I'm going to do today.

I have suggested that it's very difficult to project with precision the future, but I think we can identify what I would refer to as forces for change. Some folks refer to these as revolutions. I think you can make the argument with regard to several of them that they are, indeed, revolutionary. But the fundamental point is that, in my judgment, if you look at the landscape through which we must pass into the future, the salient features are dramatic changes in the international political system, the rate of technological change, the ubiquity of information and the ecology.

It will come as no surprise to you if I start off with what I refer to as a revolution in international politics. That's the subject I taught here at the Air Force Academy. I remember asserting in my classes that when you have new answers to three fundamental questions, by definition you have a revolution. Those three fundamental questions were: Who are the players? What are their capabilities? What are their intentions with regard to one another?

I would assert that there have been new answers, if you will, to these three questions on at least six occasions in the last 200 years. Starting with the French Revolution in 1789, the new actor was democratic France. The new capability was the citizen army; for the first time, a capability existed to fight a total war. The new intentions had something to do with spreading the gospel of liberty, equality and fraternity throughout Europe.

In a similar fashion, new answers emerged to these questions on each of the following occasions: The Congress of Vienna, where Metternich and his colleagues sat down and essentially redivided the map of Europe. The unification of Germany, the new actor being a powerful nation-state. The Treaty of Versailles, in which an attempt was made to create a new actor called the League of Nations. Post-World War II agreements and, most importantly for our purposes today, the post-Cold War period. I would submit we currently are in the process of seeing new answers emerging to the three questions I identified, and this most recent process started in about 1989.

In fact, I would suggest that there is a new answer to another important question that one might add to that original list of three: What are the nature and intensity of the interactions among the major players? Perhaps the best way I can articulate this point is

to come out of the closet as an auto-racing buff and tell you that when I first went to automobile races nearly 50 years ago, the cars were derivatives of Model-T Fords which screamed around old horse racetracks in northern Minnesota. Occasionally, you would see an enormous amount of dirt and debris flying; and when it all settled, there would be a car on its top with the driver brushing the dirt off his sleeves as he waited for the tow truck. That was 50 years ago.

I still watch automobile racing, but I almost never see a single-car accident. Today, when one of those race cars goes topsy-turvy, it normally takes with it a half-dozen other cars. Now why is this? It's not because the race cars--the actors, if you will--have become less skilled. The cars today are more maneuverable than they were in the past. It's not because the drivers are less capable. They're also probably better than they were in the past. It's not because the nature of the racetracks has changed. They still tend to be oval-shaped.

I would suggest that what is really at play has something to do with the velocity and the complexity of the relationship among those actors on the track. And I think there's a very real similarity between that situation and what is going on in international politics. In both cases, the intensity of relationships among the actors has increased in complexity to the point where crises seldom are limited to a single player.

In essence, I'm suggesting that if you quantify discussion to this point and plot it over time, you will have one curve rapidly ascending. That curve relates both to the numbers and to the types of actors in the international system. It also relates to the kinds of capabilities associated with international relations and to their increasing intensity.

The flip-side of this curve is that both nation-states and traditional alliances are tending in many respects to have less capability for achieving their objectives. If you think about it, for the last three or four years we've fought only in so-called "coalitions of the willing." Our alliances have become ad hoc, cobbled-together structures in place of the more traditional NATO-like entities.

Similarly, the nation-state of the past could do much that it can no longer do today. As I served in Moscow, between '87 and '89, it was impossible for me to get current news from the States when Soviet authorities chose to jam radio broadcasts. Nation-states were capable in those days of essentially blocking off even the passage of information. That's no longer possible in this age.

A second revolution, I would suggest, relates to technology. To be sure, we've had technological innovations in the past, starting with the stirrup that first allowed soldiers to stay on their horses and fight, and continuing through such things as the steam engine, the internal combustion engine, aerodynamic vehicles and so on. But it does seem to me that the speed or the rate of technological innovations, if you will, is dramatically increasing. And that, I would assert, has a real impact on our military profession today.

I would offer as a footnote that increased technology also has an impact on how we're organized. While assigned to the Far East in the mid-'60s, I was a photo interpreter who derived information from photography relevant to warfighters and defense policy makers. The workhorses for aerial photography in those days were two types of tactical aircraft, the RF-101 and the RF-4. During the Vietnam War, they were deployed "up front," if you will, at Thai air bases like Korat and Udorn and interspersed with the fighter bombers. The photographic missions were planned and flown from those forward operating locations, they were recovered at those locations, the film was developed there, and the intelligence officers analyzed the film at the forward locations.

Then we brought in the U-2 aircraft. The U-2 was one step up, if you will, on the technology ladder. And I noticed that when the U-2 came, it had its own set of trailers for processing and exploiting the imagery, and they were parked behind the headquarters building at Tan Son Nhut.

The next step up the escalation ladder, technology-wise, came with the SR-71 "Blackbird" reconnaissance aircraft. It was only after a lengthy discussion with Strategic Air Command, who owned the SR-71 in those days, that we were allowed even to develop the film in theater. And we ended up doing it at a distant reconnaissance technical squadron in Japan.

Finally, we moved to reconnaissance satellites. And with that we made the full organizational retreat, if you will. They were managed in Washington, the cameras were turned on and off in Washington, the imagery was developed in Washington, et cetera, et cetera. The point I'm making, then, is that with the rapid increase in technology has also come a distinct movement toward centralization of our military structure and mode of operation. I think you would find the same thing in the private sector.

In the days of World War II, a standard air strike package required bombers, air escort, air defense suppression, and so on. Indeed, it took 132 crew members to accomplish a typical long-distance bombing mission.

As we moved into the Vietnam era, we were able to chop that down somewhat. But with Stealth and precision weapons and, finally, the B-2, we end up with a situation where two B-2s and a crew of four can do almost the same as what was accomplished with those 132 crew members during World War II. This is another revolutionary impact of that technology I talked about.

If I were to try to plot the impact of technological innovations over time, here's how my graph would look. Once again, the curve depicting the rate of technological change, the lethality of weapons, the accuracy of weapons and so on would soar dramatically. But at the same time, as those weapons became very expensive, the curve depicting the quantity we could deploy would go in the opposite direction. The B-2 is a

classic example. We have 20 B-2s; that's probably all we can afford to operate into the future.

A third major factor for change is information. There has already been discussion of this revolution at this conference. I thought the Secretary's remarks on it yesterday were fascinating. As a point of departure, I would like to refer you back to the Tofflers' book, *War and Antiwar*. I don't know how many of you have read it. The Tofflers have performed a useful service, I think, in providing a framework for looking at how warfare is accomplished. In essence, they suggest that nation-states tend to fight wars like they create product. "Wave One," pre-industrial era, agrarian wars were fought with picks and spears. Next came the industrial age, with nation-states trying to destroy each other's industrial capabilities using massive force. And finally, the Tofflers suggest that in this "Third Wave" post-industrial age, information will play a substantially greater role in the circumstances under which we fight.

Note that they use the word "wave." They do that to ensure that we do not assume that types of warfare must occur seriatim. All three forms can exist simultaneously; and, indeed, the Tofflers maintain that at the present time we have at least wave two and wave three, if not wave one forms of warfare as well.

Now, the information revolution brings a different tendency with regard to organizational structure. Some of you in this room may remember that when we brought computer technology to the Air Force Academy, there was a huge mainframe, and it went to the Department of Computer Science. The Department of Computer Science professors became, if you will, the high priests for information. They would pass it out to the rest of us, essentially as they saw fit. I'm exaggerating a little bit, but the point is that control of information tended to be centralized.

Then came personal computers and the corresponding decline of the mainframe as well as the authority of those high priests in the Department of Computer Science. What emerged with the personal computers was a capability for all of us to participate analytically without support from a central mainframe. This was an early example of information's thrust toward decentralization. In a similar manner, when the F-16 pilot can receive almost all the information he or she requires to fight effectively, you may not need some of those intermediate-level headquarters that we've developed over time. I'll return to this point later.

I borrowed this graphic from a friend, Lieutenant General Jim Clapper, who recently was head of the Defense Intelligence Agency, because it illustrates very well the impact of information on warfare. During World War II, it took about nine thousand 2,000-pound bombs to destroy something similar to Fairchild Hall; during Vietnam, only 176 such bombs; and--as we know from CNN--only one such bomb was frequently sufficient in Desert Storm.

Why? Well, a major factor has to do with the amount of information associated with the delivery of those weapons. It took 9,000 bombs to do the job in World War II because only 20 percent landed within a thousand yards of the target. We were spreading them all over the countryside. As we were able to apply increasing doses of information to the delivery of those bombs, the effectiveness increased and the quantity required for mission success dramatically decreased.

So if I plot the impact of information on warfare over time, once again we find a curve with a dramatically increasing positive slope. At the same time the cost curve for information dramatically decreases. I'm told that the cost per bit of information decreases by something like 50 to 100 percent every 18 months.

Finally, there are very important changes underway in our ecology. I was recently in the Middle East, and a very astute Egyptian diplomat observed, "You know, the real security problem here is lack of water." And then as I reflected on what recently happened in Rwanda and Somalia, it seemed to me that tinder boxes, if you will, were created by a shortage of arable land, a shortage of potable water, and other factors relating to the ecology and environment.

The point I'm trying to make is that there's a lot more than the health of spotted owls involved in the notion of ecology and environmental change. I believe that it impacts directly on how we fight and the circumstances under which we fight. And with this in mind, I put together a graph with a dramatically increasing curve for population and pollution and a negatively sloped curve for arable land per capita, potable water per capita, and so on.

Incidentally, I ran into a real intellectual buzz saw with this. It turns out that among scholars who know a lot more about this than do I, there's dispute over the nature of future population trends, over the extent to which we're going to be faced with environmental crises and so on. About the only agreement concerned the increase in pollution. Last week, however, the *Washington Post* carried an article which suggested that our Secretary of State has now come to look upon what's going on in our environment as a very major factor in our national security situation.

Let me quote from the *Washington Post* clipping: "Christopher puts environment high on diplomatic agenda. He sees parched fields, poisoned air, toxic waters, rampant disease and societies driven to armed conflict by competition for dwindling resources all potentially threatening to Americans. It was those threats that impelled Christopher to proclaim a new definition of national security, and a worldwide shift in the objectives of U.S. diplomacy. Christopher set environmentalism as a top priority in addition to traditional goals such as preserving peace..." Well, the point is clear. There are factors in our environment that also may exert revolutionary changes in our security situation.

With these revolutionary changes in the international political system, technology, information and the ecology in mind, a group of defense scholars has asserted that we are

experiencing a "revolution in military affairs." Consistent with this notion, they repackage traditional air, sea and land forces into precision strike, information warfare, dominating maneuver, and space warfare. I don't know whether they're right or wrong; I am concerned with a somewhat different issue today.

It's at this point where I will get a little crazy. Some of you may well think I have gone off the deep end. I think it was Garrison Keillor who said that when you're raised in a small town in Minnesota by Norwegian Lutheran parents, a certain sense of rebelliousness comes easy. I can identify with that. I'm also within one year of retirement, which tends to give one a certain intellectual flexibility.

In any event, I would like to draw from what some of my friends these days in the chaos arena tell us. If you take a faucet and turn the handle just a little bit, you'll get a drip, drip, drip, drip, drip. If you plot the time interval between those drips on an x-y graph, you will get a single point in every instance. And if you don't fiddle with the faucet, that point will not move. If you turn open that faucet a little more, you get quicker drip, drip, drip, drip, drip, drip. But again, if you plot the time interval between those drips, you'll get a precise point. And just as a matter of interest, if you connect those points, you get a 45-degree angle.

That's the linear world. That's the world those of us who have spent most of our time in the social sciences and humanities learned to love. It's the only world in which I felt comfortable. As a cadet I would be disgusted when my answers to engineering problems didn't come out as precise, whole numbers. So far as I was concerned, the linear world was the real world. What I couldn't fit into that world, I tended to disregard.

But there's another world. If you continue to turn open that faucet, suddenly you will get drip, drip, drip--drip--drip--drip, drip and so on. And if you plot the time interval between those points, you get a pattern, a whole series of points. That's the nonlinear world, and I am coming to appreciate that more often than not, it is the real world. The comfortable world of linearity and easy mathematics, however appealing, is not the world that we face on a day-to-day basis. Regrettably, most real-world issues cannot be portrayed with straight-line equations.

Now, let's go back to those graphs I talked about earlier. I would suggest that if you package together what I said about international politics, ecology, technology and information, you get cumulative curves with dramatically increasing and decreasing slopes. The net effect is a world which is not susceptible to easy mathematics, which is non-linear, and in which inputs are not necessarily proportional with outputs. It's a crazy world where you can shoot down a small corporate jet with the Presidents of Rwanda and Burundi on board, and more than 500,000 deaths result. It's a world, then, in which very small inputs can result in enormous outputs. It's an unpredictable world in which we are faced with those patterns that I talked about earlier rather than precise points.

I don't know whether this is a new world or one we simply failed to recognize in the past. Indeed, I'm not sure where we fall on the curves I have described. But I would suggest that at some point, the totality of ongoing changes in the international system, technology, information and the ecology has fundamentally altered the very nature of what it is we're about in our profession. I would argue that the same has occurred in the private sector, as well.

Perhaps I can demonstrate the point with what little I remember from my student days in astronautics. The first college-level astro course was taught here at the Air Force Academy. I recall working our way through trajectory equations as the course went on. I also recall the aeronautics folks saying, "There's no such thing as astro." The physics folks said, "If there is such a thing as astro, it should be in physics." And the poor astro folks were working in the middle of those two vultures.

I seem to recall that there was a mathematical equation for a ballistic trajectory. If you inserted the time dimension in that equation, you could, with great precision, determine where that ballistic rocket was on its path. That's how I remember that old, predictable world in which I was educated. But then we added to that rocket the capability to learn en route, the capability to alter its course as a function of new information. The moment we did that, the world of easy math disappeared. The trajectory equation that I had memorized no longer worked, and we were in much more complex world.

Well, what does all this mean? Let me offer the following quote from a zoologist: "We like patterns--we like patterns in waves, we like patterns in a fire, and we see a flock of birds in the sky and we see a pattern in the overall movement. That's the beauty of the whole system, but it's also the thing that screws up human investigators."--William M. Hammer, Zoologist

I think there is something to the notion that we like to put things into a linear world, a world of recognizable patterns, a world where we can predict with precision. Unfortunately, this tendency also tends to screw up our investigations.

If you buy some of the notions I have suggested, I think you must agree that warfare has become increasingly organic. The old days are gone when targets tended to be fixed and when you were able to predict with reasonable precision what your opponent was going to do. Unlike those days, warfare has taken on a new complexity in which both antagonists are capable of learning while the battle progresses. The "set piece" has become a ballet.

When Admiral Bill Owens, the former Vice Chairman, talked about a battlefield 200 by 200 nautical miles about which you could know everything as it happened, and within which you could hit any target with standoff weapons, he came very close to describing a complex system, a system that is capable of learning almost like an

organism. The battlefield itself became organic. Chance and complexity made prediction almost impossible. Decision times were dramatically shortened.

Well, what does this mean? I would submit it means that information and agility have become much more important relative to mass in warfare. If you can't prepare with precision for the future, the best you can do is posture yourselves to react quickly. It was this notion with which the former Soviet Union military had serious problems. While serving in Moscow as the Defense Attache in the late 1980's, I hosted several visits by the American Secretary of Defense as he resumed military to military contacts with his Soviet counterpart. When he learned that we both were squash addicts, he instructed me to set aside 90 minutes each afternoon so we could play in the American Embassy gymnasium.

So I worked a schedule with the Soviets such that negotiations between the Defense Ministers would go until 2:30 PM, with a break for squash until 4 PM, whereupon the meetings would resume. Now that presented a very difficult challenge for the Soviets, because they were accustomed to transporting VIPs in a lengthy caravan of automobiles with red lights and sirens. It turned out they could do this effectively from the main hotel in Moscow to the Ministry of Defense, but they could not do it to our embassy, which was not located on a major auto route.

So I said, "Well, I'll help you out. You take the Secretary in the caravan to the hotel. I'll pick him up in my staff car, drive him over to the embassy. We'll play squash there; I'll drive him back to the hotel, and you can take him in the caravan back to his meeting." That was the agreement.

Our squash tournament continued for, I guess, three days. On the last day, which was going to determine the champion for that visit, the game went a little long. I said, "Mr. Secretary, we really must stop because you need to be back." He responded, "No, we'll finish." So we finished the game; the Secretary won the series; and we were late leaving the Embassy.

As we were driving back to the hotel, I was astounded to meet the official caravan going the other direction. So I joined up with the caravan and followed it to the Ministry of Defense. You can imagine the reaction on the part of a formation of Russian generals standing at attention on the steps when the lead car drove up and no Secretary emerged. When the official meeting had resumed, I asked the very brusque colonel in charge of the motorcade what had happened. He responded sternly, "Motorcade scheduled to go at 4 o'clock, we go at 4 o'clock." I never saw him again.

It really wasn't the poor Colonel's fault. The problem was that he was raised in a culture where there was no agility; everything was top down. He had the information; he knew the Secretary wasn't present, but he couldn't react, and the motorcade went on without the Principal. This inflexibility, I believe, was a major reason why the Warsaw

Pact ended up the way it did. It simply failed to appreciate the substantial implications for service structure, doctrine, and culture which have emerged with the information age.

Increasingly, information, as the Secretary told us yesterday, is the lifeblood of organizations, both civilian and military. I've spent some time recently with senior management from several major corporations in the private sector. I've learned, for example, that when Coca Cola goes to "war" in India--its opponent, of course, is Pepsi Cola--the war has very little to do with the sugar and water that makes up the soft drinks. The war has a lot more to do with how you shape the bottles, what kinds of advertising labels you put on the outside of the bottles, and how you display the bottles in the marketplace. It's the same with General Mills when they make Wheaties. Once again, the competitive battle relates as much to the person who is featured on the front of the box as to the composition of the Wheaties.

Well, just as information increasingly is the lifeblood of the commercial sector, so also is it becoming increasingly important in our profession. Indeed, it has profound implications both for how our military functions and for its organizational structure. The traditional military tends to be structured in a hierarchical fashion, with generals at the top, and colonels, lieutenant colonels, majors, captains, lieutenants, and enlisted personnel in successively lower organizational echelons. This makes for a very disciplined approach, an approach which will guarantee to get a motorcade off on time. But it's not necessarily an approach that will function effectively in the unpredictable, nonlinear age.

Well, how can we fix this? One approach that I'm sure you have studied in your classes is simply to "flatten" the organization. And, indeed, flattened organizational structures do seem to be more adept at dealing with uncertainty. But the Marines, I think, have taken a more interesting tack. First of all, they define the role of the commander as being simply to provide vision and general intent as well as to educate his or her organizational culture. When confident that the culture understands and is committed to the vision, the commander backs away and lets the organization perform its mission. As such, the organization tends to learn from the bottom up. It is not a rigid top-down operation such as that of the Soviet colonel in Moscow. I believe that such bottom-up flexibility is important to the combat challenge of today and tomorrow, just as it's what allows Pepsi Cola or Coca Cola to succeed in their competitive environments.

Allow me to offer one final example. As the J-2 at European Command Headquarters responsible for passing intelligence information to pilots at Aviano Air Base and other forward locations, I found it necessary to pass through several organizational levels. This slowed the information flow, and it arrived at the warfighter level too late in many cases. Similarly, when the warfighters on the scene passed information up the command chain, it also was slowed. Indeed, because of an iron law that says you never let a higher headquarters know more than you, the information also tended to be successively neutered as it passed through each echelon of command. In

short, we need to review our organizational structures and command arrangements to ensure they can meet the challenges of an unpredictable and increasingly dynamic world.

Well, now let's move to the bottom line as far as professional military education is concerned. If you buy what I've suggested up to this point, the notion that we can somehow do something here at the Academy, during four years, or that we can do something at the National Defense University over a period of ten months that will cover our graduates throughout the remainder of their careers, is nonsense. We can no longer rely solely on the traditional classroom experience. Somehow, we must develop an educational process that continues throughout professional careers. One answer to this challenge would seem to lie in the emerging communications technologies that for the first time are offering truly interactive distance education programs.

It also means, interestingly enough, that we need to take another look at some nontraditional disciplines. At my university we have traditionally wrapped up political science, history and economics courses and called the result professional military education. That may have worked in the linear world, but it probably is not up to the challenges of non-linearity. There are a whole assortment of disciplines that relate to systems dynamics, chaos theory, artificial intelligence, organizational theory and so on that are essential if we're going to prepare our graduates for the dynamic challenges they will face. At least at my institution, we probably have not given these disciplines their full due.

Let me close my remarks today by suggesting that our profession faces a whole new challenge as we move into a world which increasingly resembles a floating craps game, both on the fields of battle and in the arenas of high policy and strategy. As a result, it is probable that we must change our culture in substantial ways. Perhaps a new draft Marine document on command and control which I recently read makes the point even more vividly. It begins with a 35-page story about what command and control is all about in the new world. The story ends with the following quote:

"The military expeditionary force commander or the Marine expeditionary force commander sipped his coffee and gazed at the large situation screen. "Well, what do you think, Dick?" he asked. "What do I think?" Westerbee (phonetic) said. "I think we went in with an unclear picture of the situation and it only got worse. I think the enemy showed up where we least expected him and caught us with our shorts down. I think our planes were stuck in the mud and our vehicles were bogged down. I think our com went to hell and you were incommunicado for six hours at a time. I think all our best-laid plans went down the tubes, and we had to improvise and turn the whole thing over to junior commanders.

"If not for a Cobra pilot with a good pair of eyes, and a company commander with a penchant for ignoring his orders" "Yes," said the general, with obvious satisfaction, "don't you love it when the system works to perfection?"

When he was last at the National Defense University, General Shalikashvili, who is my boss, said, "What we need in tomorrow's professional military, in today's professional military, are folks who can name that tune after the first two notes." And that, in a nutshell, is what I've been talking about today.

Preparing Air Force Academy Graduates for the Air Force of the Information Age

General James P. McCarthy, USAF, Retired

Education in the Information Age Conference

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United States Air Force Academy, Colorado

Thank you very much. Madam Secretary, General Stein, gentlemen at the head table and other conferees, I'm honored to be here. For those of you who are at the Academy, you heard the Dean say that I could speak for as long as I wanted and say anything I wanted to say; so here goes, Dean.

Secretary Widnall's keynote address described the Air Force of the future and charged us to recognize the impact of information technology on our mission. Specifically, I remind you that she said that all of our officers must be competent and comfortable in the information environment, and that we should apply information technologies with very careful thought.

Please consider my remarks, then, an extension of her thoughts yesterday. I'll try to avoid repeating anything that she said, but merely amplify those thoughts and apply them to the Air Force Academy and, I think, as well, to Air University and National Defense University.

My presentation has basically three main points as I was taught in Squadron Officer's School. The first one is that the Air Force of the future is a technology force that demands leaders comfortable in an information-rich environment. Second, that new approaches for information support to education--I chose those words carefully--information support to education can enhance the Academy's mission. Finally, a plan for the future will give us the resources and the infrastructure required to meet that future.

The value of changing our approach, which I advocate, involves the quality of our graduates and more effective use of our time. Information technology properly used will improve our academic program -- in fact, the Academy's overall program. Since I was first here in 1964, cadet time has been the coin of the realm for developing program improvements. The new approach will help instructors, as well. There are many time-consuming processes that can be changed to give us more time for reflection and discussion, and that's what my presentation's all about.

A reminder of Secretary Widnall's comments yesterday about the information-rich environment of the United States Air Force today and projected into the future. I have four examples:

The F-22, with its supersonic cruise and maneuverable Stealth characteristics is certainly a valuable contribution to the fighter force of the future, but the integrated

avionics, with sensor fusion has been described as exploiting the concept of information warfare. In fact, the Secretary of the Air Force has previously described the F-22 as an information platform.

Look at the airborne laser defense program, which has the speed-of-light capability to kill ballistic missiles during the boost phase by using adaptive optics to form laser beams through a formable conveyor that puts a megawatt of power in less than a micro-radian space some hundreds of kilometers away. It uses a control system for integrating sensors, tracking, an execution to accomplish these functions faster than the human could ever possibly do it.

Take what I call the battle-space infosphere or WarNet or whatever you choose to call this effort to put together a system of systems, that brings together all of the possible combat information. It provides the battlefield commander and all of the warriors down to the individual soldier or airman the necessary information for accomplishing their function. Then we have integrated situational awareness provided by information technology.

The last example is in the support area, where the logistics management systems are being developed. Products that are important to us, when being manufactured, will have very small transmitters buried in them so that they will remain available throughout their life. They can be interrogated in a variety of ways so that when those products are put in some type of container with a tag with 128 kilobits of memory can be read by sensors that are remotely placed in the area. In-transit visibility concepts track this tag wherever movement occurs, so that an asset manager has the instantaneous capability of determining the amount and location of assets. For example, when the tank gun is fired, that round is automatically ordered through the system back to the manufacturing process.

The common element in these four examples is that information technology enables combat capability. The purpose for which we use our military forces or their support functions is basically unchanged from the use we put them to today, and they're flexible enough to adjust to the needs of the future.

Now, the Air Force is clearly the leading element in this adaptation of C4I for its military mission. In fact, if you look at the '97 budget, the amount of money that the Air Force has placed in this area equals the amount of the Army and Naval forces investment together.

The Air Force leadership has supported this improvement by putting their money where their mouth is. Despite the 40 percent reduction in the investment in military forces in the last ten years, the increase in information technology is constant over the years.

The Chief's comment is germane. The information technology explosion has made information dominance a core capability that our Air Force must attend to, because dominating the information spectrum will be critical to victory the next time the balloon goes up. He's illustrated that to the Air Force leadership by issuing a laptop computer to every general officer selectee, and recently sent them all an E-Mail message to see if they understood what he was talking about.

Now, the question I have for you today is: can we translate information technology into an education enabler as it has enabled our combat capability? After all, our society and our military are being transformed. Why not transform our environment in education the same way? Many of our ROTC and OTS graduates in their education programs may be being exposed to the use of information technology in education more so than we are here at the Air Force Academy.

Now General Cubero mentioned my work with the Defense Science Board. There are several conclusions that I come to that are germane to this discussion. The first one is that the commercial products, either available today or being developed by private enterprise, defy our expectations, and we just cannot identify all that is available to meet our needs.

Part of the problem is technologists and users don't communicate very well. I can tell you from my own experience on active duty. There were lots of things I wanted to accomplish. I had no idea that there were all these tools out there that I could bring to bear. One of the functions I perform in the DSB is to bring people with technology together with operators to make them work together. I think that's important.

Digitization permits transport and integration of information. You can take that information, and do wonderful things with it. You can correlate it, you can integrate it, you can aggregate it; and as you do, you add value to that information.

We discovered while we were heading down that path of creating this battle space infosphere, we had forgotten an important effort. In the Defense Science Board on Defense Mapping for the Future, we learned that there was no common reference system for relating information. We recommended the defense mapping agency mission be changed from publication of maps to providing a geo-spatial temporal database on which we could add pieces of information to bring greater value.

Presentation of this information in the proper way aids assimilation. I would point to your weather channel, which most of you see periodically. Probably five years ago you didn't know much about weather. You listened to the radio to a person describing things to you, but when they made moving displays on TV and you saw clouds or precipitation move across the map, you began to understand patterns and relationships, and soon you knew a lot more about weather, learning it almost by osmosis.

And so we've learned that these visual relationships aid human understanding. Information technology permits both easy manipulation of data and changing displays quickly for assimilation. You can increase the amount of knowledge that you can pass in a shorter period of time; and, therefore, we say that information technology enables.

The bandwidth we're providing now enables the sharing of this knowledge among lots of people. The consequence is that we have the promise of very robust systems to enable us to do what we need to do.

I have three examples that I would like to use, and the first one is about Desert Storm and the Iraqi headquarters. It took several analysts months, looking at all the intelligence inputs, to determine that a hotel in downtown Baghdad was actually a headquarters that had not been previously discovered.

After the war, we took that same amount of data and put it into a set of computer data bases, and integrated it so that you could take your mouse and point and click on a 35-mile radius of that location, and immediately pull up all of the intelligence inputs--SIGINT, Imagery, HUMINT--and pull that all together in single time and space. In a matter of about ten minutes several different analysts identified the location of the headquarters from that correlated information.

I'll tell you a story about Joint-Stars. I had worked on J-Stars since the early 1980s, and always it was described as a system to see enemy movement. The Army wanted it to kill tanks and trucks. When I was over in Europe, we brought over the J-Stars for an operational field demonstration. Lt. Gen. Freddy Franks, who led the famous left hook, was the Corps commander who provided the forces to exercise this system.

What he said was revealing to me. I had never heard it before, and I don't think anybody else had. He said, "I can not only see the enemy forces, I can see my own forces and I can understand the relationships between those forces, which is the most important thing of all."

Why did we not have the vision in all of our efforts to anticipate this full capability? Why did it take ten years before that was recognized? During the R&D phase, it was never discovered or understood, and it should have been intuitive.

Let me tell you a story about Bosnia. Secretary of Defense Bill Perry asked four of us to go over to Europe to see about support for Bosnia operations. The Secretary of the Air Force described yesterday how she visited the center at Vicenza and all the modern technology that is all commercial software and hardware, a result of our recommendations.

One of our recommendations was to put commercial capability to expand the bandwidth to all units down to battalion and squadron level. The Secretary of Defense

approved that recommendation, and DARPA has put together a commercial program that in three months now gives a combat unit that previously had 9.6 kilobits of information flow coming into them and increases it to 40 megabits. Now they can get imagery in 27 seconds that took three hours to transmit. The problem is that those units now don't know what to do with all that bandwidth. The growth has been so instantaneous and so expansive, they don't know how to deal with it.

Now, all of this work that I've been doing with the DSB has caused me to do some research in the application of information technology here at the Academy. I've come across one credible academic assessment that I pass on to you, and it deals with an Institute of Defense Analysis report to OSD. It makes these conclusions:

Interactive instruction was more effective than conventional instruction in higher education. In 14 comparison studies, the average increase in achievement for the 50th percentile student moved them to the 75th percentile. The interactive instruction can be both equally effective in both knowledge and performance out-comes. The more the interactive features of the technology were used, the more effective the resulting instruction. That's pretty compelling data. But then I would ask the question: does our observed experience here support those same conclusions? And I guess my assessment is it's kind of a mixed bag.

We have some great successes at this institution. I won't identify those because then I would have to identify some of the disappointing failures. On balance we're making progress, but I would suggest we're not approaching it in the right way.

I've also done a survey of cadets and faculty members, and they share the assessment of a mixed bag, with a degree of frustration in using information technology to do what it is you want to do. In my own personal experience, I'm using technology in the classroom today less than I did when I first arrived here nearly three years ago.

I remind you of General Wakin's caution at one of his speeches. He is a man whom I've known since 1964 and for whom I have great respect. And his caution--I'm summarizing, which doesn't give it all the credit that it deserves--is that we need to focus on purpose and values. He's concerned that the classroom preparation time, as he was observing it, was 10 minutes of doing background research, and 50 minutes of trying to put it all in the educational technology so the instructor could present it in the classroom. He is also concerned about the lack of professional discussions and personal interface that that kind of time-allocation produced. So, clearly, we have some barriers to overcome to meet our objectives.

First, I suggest to you that our process is inverted, and that's the fundamental message that I'm trying to convey today. We're trying to fit academics into technology, and we need to do the reverse. We need to stick with the academic principles, our basic ways of teaching, and then use technology as an enabler to do them better. I'm going to give you some examples.

Second, it takes training, it takes knowledge; and the cadets and the faculty probably do not have sufficient training to operate in an information-rich environment. Also, our information infrastructure, as much as it's improved, is not fully developed yet.

Our biggest impediment, our attitude and experience caused by these barriers, has produced a fear that the technology will take away our passion for teaching and learning. In fact, technology will be able to enable us to pursue that passion even better.

Now, overcoming these barriers requires inverting our present approach. I think we begin with the Academy's long-term planning process that we've talked about several times in our discussions thus far in the conference. The seven educational outcomes for our goals for education are an essential starting point. Let me take just a second to remind you of them. Cultivate intellectual curiosity; communicate effectively; frame and resolve ill-defined problems; learn from others; become an independent thinker/learner; understand and integrate knowledge; synthesize knowledge to create and perform. What a wonderful list on which to begin an approach that transforms technology as an enabler.

Equally as important is the Dean's process for change that he's introduced to the institution. I suggest to you that conceptual thinking is the Academy's answer to Dr. Vaill's white-water leadership problems that he described so effectively last night.

There are several important points that we should consider as we contemplate change. One is the need to protect our fundamental academic soundness. The cadet/faculty relationships are still the key. Principles of education, which I'll not enumerate, must be maintained. The transition phase requires clear guidance and direction, because there are a lot of pitfalls along the way.

I also suggest that our students view technology differently than most of us do. It is ubiquitous and transparent to them. The view they have of it is like the way we view chalk. Think about the last time you were in a classroom, and you wanted to illustrate a point that you could not make verbally, so you walked over--subconsciously, even--and picked up that piece of chalk, and you started drawing on the board. You conveyed to the students some new concept or idea better than you could do just with your mouth or hands. The consequence was you saw them grasp an idea that you couldn't convey previously.

Information technology has to have that same transparency. You should walk over and you hit that computer button without thinking about it, to display the information that supports your point.

The other important thing is that there's a lot of experience that's developed in the last three or four years in the Air Force that makes this all possible. There are lessons that they've learned very painfully, and I suggest the most important one is that you need to support the primary function. In their case, combat capability; in our case, education. That ought to be the principal goal; and information technology is the enabler.

The Air Force has learned how to deal with problems like system assurance. Commanders are very impatient when they're gathering information to make a decision, and the system goes down. That only happens a few times before it's fixed and fixed good. I would suggest to you we need to apply that same kind of service assurance and system protection to the Academy that we've applied to our combat forces.

One reminder before I describe my vision for the future. This discussion is not about technology, it's about process and change. Technology is only the enabler that permits us to do things we could not do before.

I'm going to try to describe a vision for the Air Force Academy and the information age in the future. It isn't achievable tomorrow; it is where we should be heading as a goal. It's an information-rich environment where the cadets' and faculty and staffs' daily activities are supported by information systems. Classrooms and laboratories have a full information infrastructure. The library, the visual center, the training devices are fully digitized and on distributed data bases for full access. Easy research access to the libraries of the world is available. We break down all the walls, and we use whatever information is available, and a lot is available not just on the Internet, but within the DOD systems that we can use with the proper authority.

Now, the cadet information systems need to change, as well. Think of each cadet having a very robust laptop computer with a docking port in the dorm room and a docking port in the classroom. A docking port is simply a device that gives them access into the local area network and the power supply.

The cadet also has a keyboard and monitor in the dorm room that he can use when he's doing intensive academic activity and doesn't want to use the smaller devices. The concept also includes a personal printer so that a cadet doesn't have to go down the hallway or stand in the queue as they do now. How many of you have had cadets come in and say, "Here's the disk, but I can't get it through the system to provide it for you?" Quite frankly, I prefer it on the disk.

Now, loaded in that computer at the beginning of the semester is the cadet's activities for the entire semester; not only all his academic schedules by day, by class, but all his athletic activities, cadet chorale practice sessions and performances. The data is automatically input at the beginning of the semester.

Now you have an information foundation for the cadet's support. If you want to change the schedule of calls, it's pretty easy. You send it out on the system.

You can also give exams as we do now on away trips but electronically. You can put a quiz in the system, giving the cadet a time lock so that they must begin at a certain time and complete within a time limitation. When they return they simply dump the quiz into the system.

The instructor's improvements in support is very similar, except he has different tools for creating lesson plans. You give each instructor a dock to work at home so that they can call in if they choose to and operate at least part of their systems like E-Mail. You have information support systems that operate 24 hours a day to provide you, if you're working at home at 3 o'clock in the morning, the necessary help if you have a problem.

You have training centers that produce a minimum level of training to operate this system for both cadets and instructors.

Now, this is creating an information environment. One does not use an environment, one lives in it. That's an important distinction, and that's my interpretation of the Secretary's remarks as she made them yesterday.

So, how do we use this new information system? I'm going to limit my example to only one, and it has to do with the cadet accountability system. For those of you who are assigned here, it is a historical system in which the instructor fat-fingers in a cadet absence, usually in five lesson segments. Then the disk is sent someplace unknown, and comes back about four or five days later so you can enter the next five lessons. We have a good historical record, and a good way to find cadets who have not attended classes when they should.

Just think of a new scheduling support system that can be implemented now. Use the scheduling information already existing to aid the cadet by providing it in a more useful form. Our new system would provide each cadet with a schedule of all activities for the semester: academic, athletic, clubs, military training, and Scheduling Committee-approved absences. Faculty and supporting staff would have access as necessary to the information. You now have an anticipatory system where an instructor teaching a cadet who is having some academic difficulty can go immediately to the data base and identify the past absences and future excused classes. When an instructor is considering the academic deficiencies of the cadet, he will have the perspective of past absences and future scheduled absences to assist in considering a course of action to help the cadet successfully complete the requirements of the course.

More importantly, the cadet's perspective of scheduled activities will aid him in time management to meet the numerous academic and other requirements.

The important part of this new approach is you identify the education process that you want to accomplish, and then you use technology as an enabler for that process. This morning, Dr. Laffey took a slightly different approach. I think his argument was you need to change the process.

I think that you start with the process that you want to implement and apply the technology to it. It is the only way that you can accomplish the desired result because the educator does not understand fully what the technology will provide. It's better to start

with a known process and then alter it gradually than to try to change the process dramatically. Other than that, I agree with the basic parts of his excellent presentation.

I could give you several other examples of the same kind of system using a process that is electronically supported for academic evaluation or admissions for cadet candidates.

Does the vision change the fundamental way in which we teach? I think not. The way we teach on a day-to-day basis? Yes, I hope so. The consequences of the new approach, then, are better education; support for the instructor and for the cadet; dramatic reduction of administrative functions. Interdisciplinary approaches are enhanced because now you can bring a variety of different sources to the academic classroom; and probably most important, instructor and cadet time reallocation to more effective learning.

All of this takes a plan for beyond the year 2000. The first step is for an institutional commitment to the vision, and then establishing the organization or structure necessary for developing a plan. I suggest using the process approach is fundamental to success. So the place to begin is to look at all of these difficult processes that exist today and decide what would be the optimum that you can envision for that process, and describe that in sufficient detail, and then let the technologists tell you how you implement it using information technology. I am struck by the similarity of the technology necessary to implement almost any conceivable process. Then, continue to improve the infrastructure so that it's ready for this vision.

Build this multi-year plan with such fidelity and such detail that it's effective for Air Staff evaluation. Training for the cadets and faculty needs to begin now, not when the plan is approved and implemented. And I think, and this is a judgment, Madam Secretary, I think that with the proper developed plan, a reasonable approach to get there, the Air Force leadership will support the change to move the Air Force Academy and other educational institutions to the leading edge of the application of this technology, as they have in the past. With that Air Force leadership support and other funding, the necessary resources will flow.

Now, that's a pretty ambitious undertaking, and all I'm suggesting for this conference is an evaluation and a start on a process that takes us to that vision. The important point is to produce a better qualified graduate who's comfortable in an information environment. You notice I never once said to teach them about information technology. The basic principles that we are trying to establish here are important.

Time, this commodity we are always looking for, will come from this process. Will the cadets have more time? Never. Will they be able to allocate their time to more effective purposes, whether it is academic study or recreation, relaxation? I think so.

I issue a challenge to you; I hope the conference is up to it.

Einstein on Education

Len Barron

Education in the Information Age Conference

April 17-19, 1996

United States Air Force Academy, Colorado

Thank you General Cubero for the kind introduction. General Stein, General Hopper, Dr. Wilson, members of the faculty we honor today, distinguished guests, and ladies and gentlemen.

It is nice to visit the Academy for the second time. The first time was in the summer of 1962, about a year after I had moved to Denver from Boston. My folks came out to visit that summer and one day we drove down to Colorado Springs to see Nat King Cole at the Broadmoor Theater. On the way we stopped to take a look at the Academy.

I call my folks every weekend. We exchange weather reports and they usually ask what new place I might be taking Einstein.

When I told them I was going to the Air Force Academy - my 88 year old father, who has barely missed a beat, said to me: "Oh when you're down there, ask them if they've ever got around to fixing the leak in the chapel."

Some of us are old enough to remember that early architectural dilemma. I trust I can lay to rest my father's concern - and now help bring to light some of Albert Einstein's sentiments on education.

Probably more than any other personality of the 20th Century, Einstein is synonymous with the idea of genius. But as a genius he is different from us, or certainly most of us.

On the other hand, in his simple, straight forward, ordinary qualities, he is a model for anyone in this room or anyplace else for that matter. For in his ordinary qualities we find the roots for our grandest hopes in education.

Over these few minutes we have together, I'd like to share some stories about Albert Einstein and also what he had to say about independent thought and a world view, and some of his thoughts on children and fairy tales.

One of his assistants once asked him how aging had affected his thinking. Einstein smiled and answered: "Oh I have as many ideas now as I've ever had, only now I'm less certain which are the good ones."

Einstein's playfulness and his sense of humor were legendary in the scientific community. When folks first got to know him they were always astounded at the difference between his quiet manner and his sudden explosions of laughter. He was like a little kid.

He never lost that grand sense of play and it found expression in his daily life and in his search for the deep subtle secrets in nature.

Einstein's playfulness, in concert with his independence, was not always appreciated by his teachers. He had his share of problems during his early schooling and then later at Zurich Polytechnique where he went to college.

In spite of his difficulties he did quite well at the university and when he graduated in 1900 he was one of four students to qualify for an assistantship. His three classmates got the position, Einstein was rejected. He was bitterly disappointed, but he then sent letters to schools all over Europe.

He did not get a single reply. No school at any level had any interest in having Albert Einstein on their faculty.

It was two years after he graduated that he finally got a regular position, but it was not at a university, it was as a civil servant at the patent office in Bern, Switzerland.

As we know time worked in favor of Albert Einstein. He got his first professorship in 1909 and by the 1920's he was world famous and had long since been recognized as one of the great original minds in all the history of science.

All through that time Einstein was invited to universities all over Europe. In 1925, at the height of his fame, he was invited to give the annual address at the German Physical Society.

He spoke about his latest theory, he had been working on it for months. He talked for an hour, filling the blackboard with equations and at the conclusion of the lecture the chairman asked if anyone had any questions or comments for Professor Einstein.

In that packed hall of scientists from all over Europe there was not a sound to be heard. And then after a long pause, a young man in the back of the hall raised his hand. It turned out the student was 18 years old.

The young man said: "What professor Einstein has shared with us is quite marvelous, only the second equation does not follow from the first... it needs an assumption which is not proven."

Well, everyone in the hall turned around, who is this kid challenging Einstein?

But Einstein is not looking at the student, he turns around and is looking at the blackboard. After a moment he turns to face the audience and says: "What that young man in the back said is absolutely true. You can forget everything I told you today."

While Einstein's great intellect could be an inhibiting factor in exchanges with him, it was common knowledge that he welcomed criticism or suggestions to any idea he had.

He hated routine so he had difficulties doing calculations and his assistants would most often tend to those tasks. Once he greeted a new and awestricken assistant with some equations which had been troubling him for weeks. Within a half-day she discovered that a factor of 2 was missing and puzzled, she went to one of his former assistants to see if Einstein could have made such a mistake.

"Of course," replied the former assistant, "you found an error. Go tell him."

And so she did and soon she reported: "I got used to the idea that I could correct Albert Einstein. And he would always thank me."

Colleagues and friends, Abraham Pais and Leo Szilard said they knew no one who was as free from the corrupting influence of vested interest and vanity as Einstein. And he did not cry over spilled milk.

Banesh Hoffman tells a story similar to the one just shared. He and Einstein had been working on an idea for several months when they discovered a fatal flaw in their thinking and had to abandon all the work done over that period.

Hoffman left in utter despair and the next morning when he walked into the office he was still depressed.

Einstein took quick notice of Hoffman and said: "Banesh, don't feel bad, we now know another idea that doesn't work. We won't make that mistake again. Come, let me show you what I'm working on, it came to me out of the blue last night over a bowl of soup."

In our daily life or in physics, acknowledging a mistake can take you a long way - for when you give up a false idea, possibilities can unfold that are impossible to conceive under a previous assumption.

Mark Twain reminds us: "You cannot depend on your eyes or your mind if your imagination is out of focus."

Einstein attended the Gymnasium in Munich. The Gymnasiums in Germany, the equivalent of junior and senior high school, were highly authoritarian and students did not question the authority of the teacher.

But the 12 year old Einstein was dismayed by the behavior of several of his teachers for they were unfair in their treatment of certain students. While the students from the wealthier families in town were given special privileges, the youngsters from poorer families were often unduly punished.

Einstein was openly critical of those teachers. He was reprimanded for his comments, but it was characteristic of Einstein that he would risk criticism or outright punishment rather than be silent about something he felt was not right.

Beyond his physics, the most enduring passion of Einstein was his engagement in issues of justice. It would appear to be almost inevitable that the last document he wrote, four days before he died, was on an issue dear to his heart: Making peace between Arabs and Jews.

Einstein reminds us that there is a facet in this notion of being fair that is rarely given proper attention: In the very act of being fair you tap into a reservoir of empathy and insight. When you consider a person or a group, a problem or a particular circumstance and look with a free and unprejudiced eye, you see more.

It is simple physics. If you are fair you see more.

Einstein recalls a stunning experience when he was five years old. He was at home sick and his father brought him a small pocket compass.

"No matter which way I turned," he said, "the needle always pointed in the same direction. It made a profound and lasting impression on me. Something deeply hidden had to be behind the nature of things."

From his earliest days, what he did not know was always of more interest than what he did know.

In his later years he wrote: "The most beautiful experience we can have is the mysterious. It is the fundamental emotion which stands at the cradle of true art and true science."

There was no concept that more influenced Einstein's perception of the natural world than the idea of beauty. A conversation between Einstein and the young Werner Heisenberg is an expression of that idea. The voice is Heisenberg's:

"If nature leads us to mathematical forms of great simplicity and beauty, to forms that no one has previously encountered, we cannot help thinking that they are true, that they reveal a genuine feature of nature."

"It is, indeed, an incredible fact that what the human mind at its deepest and most profound perceives as beautiful, finds its realization in external nature. What is intelligible is also beautiful."

Einstein simply said: "Beauty is the first test."

Einstein was referring to the natural world and he was a bit reluctant to apply the same law to human affairs. The people world is certainly more arbitrary.

Nevertheless, it was clear to him that as pure form - relationships of regard and mutuality are beautiful... acts of exploitation are ugly. Expressions of thoughtfulness - beautiful... greed and arrogance - ugly.

Walking along a bubbling creek... driving in traffic.

In Einstein's manner and thoughtfulness we find the qualities we want to encourage and nurture in our students and in ourselves. Qualities all within the capacity of every one of us: Playfulness and openness, a deep rooted sense of justice, and curiosity and beauty.

There are two other considerations that Einstein would bring into a conversation about education: The notion of independent thought and a world view.

One of his last papers was titled: "Education for Independent Thought."

In that paper he writes: "Over-emphasis on the competitive system and pre-mature specialization on the ground of immediate usefulness, kills the spirit on which all cultural life depends, specialized knowledge included.

"This competitive mentality prevails in schools and destroys feelings of human fraternity and cooperation. It conceives of achievement, not as derived from the love for thoughtful and productive work, but rather as springing from personal ambition and fear of rejection.

"The lesser function of thinking is to solve puzzles and problems. The essential purpose is to decide for oneself what is of genuine value in life... And then to find the courage to take your own thoughts seriously."

As for a world view - Einstein was fond of the American philosopher William James who offered this perspective at the turn of the 20th Century:

"The course of history is nothing more than the story of men's struggles from generation to generation to find the more and more inclusive order. To invent some manner of realizing your own ideas which will also satisfy the ideas of those different from you. That and that only is the path of peace."

After Einstein settled in America he was deluged with invitations for honorary degrees. Within a couple of years he decided to refuse all such invitations. In the following years he made only two exceptions.

In 1946 he went to Lincoln University, a Negro college in Pennsylvania. For all his years in America, Einstein spoke and wrote fervently for the rights of black Americans and he was pleased to go to Lincoln and lend support to that University.

The other exception was in 1938 when he spoke at Swarthmore College. My friend Mary McDermott Shideler was in that graduating class and was kind enough to give me a copy of that commencement address.

On that day Einstein spoke of tolerance: "We must not only tolerate difference between individuals and between groups, but we should indeed welcome them and look upon them as an enriching experience. That is the essence of all true tolerance. Without tolerance in this widest sense there can be no question of true morality.

"It is a task never finished, something always present to guide our judgment and to inspire our conduct."

Towards the end of his life Einstein was asked what it was that spurred mankind forward and he returned once again to curiosity:

"The important thing is not to stop questioning. Curiosity has its own reason for existence. One cannot help but be in awe when one contemplates the mysteries of eternity, of life, of the marvelous structure of reality."

"It is enough if one tries merely to comprehend a little of this mystery each day. Never lose a holy curiosity."

With that thought, "a holy curiosity," we can better appreciate Einstein's affection and regard for children, for in the ordinary behavior of a child, any two year old, we see wonder and inventiveness... again and again and again.

Einstein loved fairy tales. He said: "If you are not deeply touched by fairy tales, the possibility of becoming a first rate theorist is very slim."

At one of his last public meetings he talked of a letter he recently got from a group of schoolchildren in Michigan. It seems the youngsters were going to start a cookie business and with the money they made from selling cookies they were going to turn Washington DC into a bird sanctuary.

And then he continued: "My dear friends and colleagues, as long as there are kids and cookies and imagination still alive in our soul... beauty and playfulness may prevail yet."

And it is in that spirit that we gather to pay homage to the art of teaching and, in particular, to those men and women whose efforts and inspiration we so gladly celebrate on this day.

It is a dear pleasure to share this time with you. Thank you.

The Future of Information Technology: A View from the New World Vistas Study

Dr. Edward A. Feigenbaum

Education in the Information Age Conference

April 17-19, 1996

United States Air Force Academy, Colorado

[Editors' Note: For completeness, Dr. Feigenbaum's "Introduction and Executive Summary" of the Information Technology volume for the *New World Vistas* report is used here instead of his transcript from the Education in the Information Age Conference.]

Some military analysts say that warfare at this time is undergoing a revolutionary change. If indeed there is such a revolution, the central element of it is information technology--the technological revolution in computers and communications. It is brought about by an underlying rate of technological progress that is unprecedented in the history of technology and military doctrine.

What makes a technological revolution? Analysis of other technology revolutions tells us that one power of ten of technological change makes a revolution. For example, automobiles transport us ten times faster than walking, and jet planes ten times faster than autos. It took half a century or more for these revolutions to change the face of modern life.

The wealth and security of this nation are increasingly driven by information and are based on knowledge. The engines of knowledge and information, computers and communications, have been doubling their power per dollar every twenty months. The pace is still accelerating. Over the past three decades this compounds to not one or two factors of ten, but six--a million-fold change. And the more powerful these engines become, the smaller they become and the more energy efficient. If this were myth rather than reality, one might say information technologists own a magic wand.

The global village--the wired world of people with shared interests--has been formed because of low cost communications. Computers are so cheap and useful that they are in everything. A tiny but powerful computer sits inside a weapon, guiding it with astonishing precision. Modern warplanes, like the B-2 or the F-22, are as much flying computer networks as they are flying airframes. The remarkable capabilities of modern radar and other imaging devices are as much derived from their computers as from the physics of their sensors.

It is a revolution when computer-assisted logistics planning for a force projection can be done in hours or days rather than weeks. It is a revolution when an accurate situational analysis can be made and given to a warfighter in seconds rather than minutes or hours.

It is a revolution when differences in IT capabilities can contribute in such a major way to a decisive military victory (Desert Storm)--a revolution in which the term "information warfare" is added to the list of future necessary combat capabilities.

The task of the Information Technology panel is to project the visible trends of the continuing revolution in information technology and, where projection fades at the horizon, to envision further progress. We have done this in two ways.

First, systematically we have surveyed the areas of IT work. Examples are communications, computer system architectures, the interface between computers and people, software and the technologies for its development, the emergence of artificial intelligence software that emulates human-like thought processes, software that learns and adapts itself to user needs, technologies for crypto-secrecy and for assured access to systems and networks, and several more.

Second, we have projected and envisioned specific achievements, stretching out over twenty years or more--highlights of the information future. Some are evolutionary, "big wins" with high probability of being achieved. Others represent discontinuities; we do not know if they will arrive but if they do, their impact will be revolutionary. Still others represent technological, educational and organizational concerns for the future of the Air Force in the era of the information revolution.

Military needs no longer drive this revolution. The good news is that often we can buy off-the-shelf hardware, software, and communications that are much better than, and very much cheaper than, what we can have custom-built for us. The Air Force is challenged to adapt to this new way of doing business, and to benefit from the best that commercial technology can offer (just as our friends and enemies can). But some information technologies that the Air Force needs will not emerge from the commercial marketplace. Our panel made judgments about what these will be as a set of recommendations for continued Air Force and DOD R&D funding priorities for information technology. Our panel also points out where the Air Force can benefit from starting to rethink right now how information technology can improve its weapon system design, acquisition, management, education and career development processes.

What follows are summaries of various IT focus areas, concluding with our recommendations.

Communications

In the field of information technology it is especially important the Air Force ride the commercial curve. The pace of technology here is arguably faster than elsewhere, and there is an enormous non-military market that keeps prices spiraling downward so long as the needs are not specialized.

The key to information technology is distributed systems, enabled by high speed computer networks. Historically the need for capacity in digital networks has doubled annually, though the applications that require growth in capacity have not been predictable. Thus it is evident the Air Force must plan for a growth in its networking capacity by about three orders of magnitude in the next ten years, and must reconcile itself to the expectation the uses of that future network cannot be foreseen. Although the prices of commercial communications have also shown an exponential decrease with time, it is not obvious dedicated Air Force networks, e.g., satellite systems, will show this same decrease.

In the near future the work will be networked with very high capacity optical fibers, using wavelength division technology with enormous capacity. The most cost effective communications will rely on fiber networks. However, in many forward locations, the Air Force will not have access to these fiber networks, so the critical problem for the Air Force will be communicating across the approximately 100-mile gap between its forward locations and the world fiber network. The other critical Air Force communications problem is enabling broadband communications into tactical aircraft from ground points not in line-of-sight to those aircraft. The Air Force will need to use satellites, airborne relays, indigenous wireless systems, and deployable wireless systems to cross those critical gaps.

At the current rate of growth most of the world's population will be connected to Internet soon after the turn of the century. The Air Force must plan for the use of this capability to optimize the efficiency of its operations, just as any other business. However, the Air Force must develop specialized skills in the defense and attack of computer networks. It is likely virtually unbreakable encryption technology will be widely deployed commercially and both network attack and defense will be raised to very sophisticated levels. Indeed, skills in the use of information technology will be the differentiating factor in the future for business, and this will likely be true in the military arena as well.

Personal Computing

"Personal Computing" is a category encompassing the information devices likely to succeed today's personal computers as commonplaces in personal and business lives. Thus this is not a category defined by technology per se; rather it reflects the convergence of technology trends from other categories, expressed in commercial products. This category is essentially one of packaging--what novel forms will various components and software be combined into?

In short, this category represents the trajectory of mass market information tools over the forecast period. Understanding this trajectory allows for exploitation of the economies of scale created by commercial deployment--including lowered cost, increased reliability and expanded understandings of systems performance. For example, if Pentagon

planners a decade ago knew what Sun, Apple and SGI would be building today, how would that have affected planning? However, such exploitation is not without risk. Incorporation of complex commercially available systems may expose users to unknown risks of penetration and reliability failures.

Finally, it is vital to acknowledge the crucial role played by different age cohorts in defining this sector. The first PCs were invented by individuals who grew up in a mainframe time-sharing world, and thus it is no surprise that the first PCs (e.g., DOS) were near-perfect simulations of what a timesharing experience would be like at a local level. Now, a new generation raised on PCs is about to enter the workforce with ideas of its own. They are certain to redefine the PC sector as profoundly into something utterly new.

Human-Computer Interaction

The next twenty years will see two important ways computers will come to serve us. The first and undoubtedly the most compelling vision is their migration from a hands-intensive tool to a delegatable assistant. The ever-affordable surplus of computing cycles will be more and more dedicated to making the computer not just user-friendly but user-like.

The more straightforward use of computers today is as a framework within which application programs are run. The processors, the connectivity, the operating systems are becoming invisible, subordinated to the applications programs at hand. Within a decade those, too, will begin to sink below the conscious surface, yielding to task-oriented computing as the next level of work abstraction. To make this possible, the way people interact with computers will take on many of the attributes used when they interact with other people. Over the next few years, speech and handwriting recognition and understanding software will permit a wide range of computer interaction now confined to the keyboard and mouse. That does not predict their demise, however.

The second compelling use of computers will be to augment the physical, not just the intellectual human. Computers offer a very flexible, yet precise means to transform what we are equipped naturally to use into realms of functionality we would have never dreamed beforehand. While the range of such use may not be as broad as more mind-centered work, there are many situations where our dimensionality, our sensory package, our reaction times, our motor sensitivities, or simply our remoteness are inappropriate to the task at hand. The most general concept of such transformation is telepresence, providing human interaction potential to otherwise inaccessible environments. Emerging now are computer-mediated tool systems that permit exquisite sensory and tactile presence from a remote location and with dimensionality scaling where needed. The handling of dangerous material, the tele-operation of large- and small-scale systems, and remote surgery are a few examples.

At the intersection of the mind- and physical-centered worlds of computer use lie new fields like augmented and virtual reality. Augmented reality is the overlay and supplementation of real world, real-time events with simulations intended to instruct or focus the attention of the participant. Virtual reality involves a totally synthesized environment for the participant in which, ideally, all senses are used. Virtual reality systems are, of course, with us now, but affordable systems that closely match our sensory capabilities are still a decade or so away.

Intelligent Software Agents

Though the notion of software-based agents have existed since the early 1980s, they are just now beginning to emerge as functional parts of software systems. The lack of a precise definition of agents, unfortunately, gives the developer and marketer wide latitude in just how much or how little functionality is present. At their best, software agents are capable of representing a user or owner in the accomplishment of specified tasks without his/her having to prescribe how it is to be done. Retrieving specific information is the most frequently suggested role for agents, but the complete range of functions is extremely broad.

We define agents broadly, as programs that have an owner, have some degree of autonomy, are goal driven and not means driven, and are able to create other processes or data. Given the predicted state of development over the forecast period, any use of agents in safety-critical situations must be guarded. The intelligence displayed by agent programs will evolve almost indefinitely. For the moment we define three levels: (1) directed-action agents have fixed goals and limited ability to deal with the environment and data they encounter; (2) reasoned-action agents have fixed goals and an ability to sense both environment and data and take reasoned action; and (3) learned-action agents accept high-level tasking and are capable of anticipating user needs based on general guidelines and can issue itself new goals in the process.

Over the next decade agents will be able to provide such functions as advising and personal assistance. Advisory agents will be able to monitor a situation and give feedback and recommendations, such as in instructional settings. Personal assistants will most likely will appear as managers of human-computer interaction, offering user assistance in specifiable tasks such as electronic mail, calendars, conference set-up, information or more general searches. They will come to represent the user in a wide variety of transactions. "Traveling" agents will be aware of the vast, network-based world of information and its indexing. Under specific requests and general constraints, they will retrieve information of all kinds, potentially operating within remote servers or hosts. They will be needed because the inventory of sources is so large, its quality so uneven, and its costs so varied that humans will not easily abide such searching.

Information Access Technology

Information Access Technology (IAT) provides the framework and foundation for accessing and transporting relevant information to the Air Force decision maker. Central in this task are the conversion of data from the many heterogeneous data resources available into an integrated information base that provides situation awareness. Additionally, IAT needs access to software for symbolic fusion and summarization. Advanced IAT services must also have access to simulation software, so the decision maker can develop and compare multiple courses-of-action within the system in terms of their potential results, resource consumption, and risks.

A critical task of IAT services is the reduction of data to a manageable amount of essential information. Integrating many streams of data further increases the volume of data delivered. It is crucial to avoid information overload to the decision-maker (whether an airman on the maintenance line, a pilot on a mission, or the commander of a joint task force), by presenting only relevant information at the appropriate level of abstraction. Information overload also has to be avoided when lower bandwidth links are to be used, often in the last 100 miles to the warfighter.

Two types of IAT modules are usefully distinguished: mediators and facilitators. A mediator performs such tasks as summarization, abstraction, and fusion at the behest of its owner. Mediating modules can either provide information according to a pre-planned schedule, or in response to a request. A facilitator, by contrast, is a module that searches the network for sources of data, and delivers newly discovered data to a mediator and its maintainer, or directly to an end-user recipient.

Multi-level, distributed IAT systems are enabled by the rapid progress in communication hardware and infrastructure technology. To gain the maximum benefit from such systems, we need experience with IAT concepts involving modern technology so rapid assembly of IAT systems will be possible, e.g., to assemble mission nets for new situations and rapidly assembled task forces.

Artificial Intelligence

The information technology called artificial intelligence (AI) is used to build software that performs the kinds of information processing tasks humans perform so well--using knowledge to solve problems, analyze situations and decisions, recognize patterns, form hypotheses, learn new knowledge, understand human speech and language, and so on. To date the technology has demonstrated limited but significant real-world uses in both commercial and military environments and is poised for widespread and powerful uses in the next two decades.

The key limitation to the AI technology has been a limitation of what AI programs know. To perform well, AI software must be more than narrowly smart, it must be broadly educated. The narrow specialty knowledge bases of today will be

expanded in the next two decades to huge knowledge bases with tens of millions (later hundreds of millions) of pieces of knowledge and know-how. Much of human knowledge will be encoded for use by both people and AI software, and will be held and distributed on the Internet. The key bottleneck in doing this--acquiring the knowledge for encoding--will be overcome by technologies now emerging that allow the automation (or semi-automation) of the learning process.

We expect that accurate understanding of human language in text and speech will reach the 95% level in ten years, for areas of limited scope and will handle broad areas of human discourse within twenty years.

Early experiments suggested that AI technology can provide a powerful expanded framework for the problem of information fusion for situational awareness, allowing fusion not just of multiple streams of sensor data, but of situational knowledge, experience, and context as well. This fusion of signals with symbols will be a key to solving information overload, as well as understanding image data and intelligence collections.

Finally, AI application will bring big changes in affordability and rapid response in the areas of designing, simulating, building, and maintaining equipment and software.

Computer-Aided Planning

Improvements in planning and scheduling over the next twenty years will provide revolutionary advances in the speed, efficiency and effectiveness of Air Force operations. Existing techniques, such as constraint-based planning, when widely applied, will provide orders of magnitude improvements in operations planning. Additional advanced capabilities will arise from capturing plan rationales (i.e., the reasons why actions are being taken), enabling for example the speedy modification and re-use of existing off-the-shelf plans. Advances in decision theory and reasoning about uncertainty will enable execution-time plan modification even in the highly uncertain environments characteristic of conflict. Finally, a variety of increasingly powerful multi-agent planners will permit the integration of concurrent multiple viewpoints and, eventually, permit planning to be done continuously by multiple teams of people and software agents working together.

Modeling and Simulation

Computer modeling and simulation provides exploration of alternatives for the full spectrum of Air Force activities, from research and development through analysis, acquisition, test, evaluation, production and logistics to education, training, and operations.

Computer modeling and simulation has been evolving its broad range of Air Force capabilities since the first use of computers for ballistics applications in the 1940's. As a result, the current Air Force inventory of independently-developed computer models

and simulations has formidable interoperability and compatibility problems. These have been overcome in some limited domains (e.g., flight dynamics models) and in some medium-scale training-oriented distributed interactive simulations such as Simnet. They have also been overcome in point-solution demonstrations and exercises linking wide varieties of models, simulations, real equipment, and operators. However, significant broad, regular-use operational issues such as interoperability, rapid configuration, and verification, validation, and accreditation (VV&A) are just beginning to be addressed.

By 2005, with a significant level of Air Force effort, basic large-scale interoperability support will be available, including consistent data definitions and fixed interaction protocols. By 2015, this will extend to dynamic interaction and interoperability agents. By 2005, simple user languages enabling rapid composition of models and simulations will be available. By 2015, these will extend to support automatic configuration of models, and simulations that address decisions such as choice of airlift capabilities.

By 2000, the Defense Simulation Internet will provide broadband support of point-solution "Louisiana Maneuvers" scale simulation. By 2010, it will be operationally robust and able to support regular exercises at this scale. Currently, VV&A technology consists of basic test suites and simple assertion checking (e.g., of conservation of energy, resources, etc.). By 2005, with Air Force investment, this can expand to simple mission-domain model checking and built-in-tests. By 2015, this VV&A technology can expand to domain model checking using automated agents and dynamic built-in-test, achieving much higher levels of credibility.

By 2015, the resulting modeling and simulation capabilities will enable combat operations options to be credibly simulated before and during combat, greatly increasing combat effectiveness. The same capabilities will enable continuous two-sided exercise of information warfare capabilities, honing Air Force pre-eminence in this critical area. With appropriate attention to acquisition restructuring (e.g., virtual competition ground rules), the technology will enable virtual system acquisition, or flexible migration from virtual to actual combat systems, with complementary closed-loop combat system exercise and improvement across the system's life cycle.

Software Development

Software development technology provides the Air Force with its best defense against tomorrow.

The other technologies addressed in New World Vistas are primarily focused on ensuring that on any given day in the future, say July 4, 2025, the Air Force is better prepared to prevail in combat than its adversaries.

However, suppose that on July 5, 2025, the Air Force detects that an enemy has discovered and is ready to exploit a critical weak link in Air Force combat capability.

What technology can best enable the Air Force to repair the weak link and disseminate the fix to its full complement of forces?

An electronically disseminated combat system fix would best fit this need. The most powerful and flexible electronic fixes by far are changes to the combat system's software. Enabling the Air Force to design, develop, test, and deploy these fixes is the province of software development technology.

Software development technology consists of methods, processes, tools, and assets enabling faster, cheaper, and better development of computer software. Methods, such as object-oriented design, configuration management, and Cleanroom methods, enable improvements in software design, verification, version control, and quality assurance. Processes, such as incremental, evolutionary, spiral, design-to-cost/schedule, and product line management processes, enable more efficient orchestration of the methods. Tools, such as design, code generation, test, product and process management tools, can completely or partially automate software development functions. Reusable assets, such as specifications, plans, components, and test cases, enable more of a software system to be composed of already-developed artifacts.

As with other information technologies, software development technology is increasingly paced by commercial investments. From an information warfare standpoint, this must be considered a technology leveler with respect to the Air Force and its adversaries. Not using commercial software development technology would be a competitive disadvantage for the Air Force, but so would a purely reactive use of commercial technology.

Software Infrastructure and Standards.

The breadth of computer use in commerce permits the military to exploit the massive investment in software being made for commerce, manufacturing, education, and entertainment. This investment will continue to drive progress, the benefits of which will be available to all: commerce, the military, our friends, and our adversaries. In this environment, speed is the key to remaining current: the Air Force must ensure that its acquisition processes enable it to move quickly in acquiring and exploiting new software.

The Air Force has a need for standards that enable interoperation that far outstrips what is likely to be produced by the commercial marketplace where individual vendors have interests in developing proprietary systems.

Progress Due to Commercial Interests.

Commercial interests are causing a rapid convergence to a smaller number of distinct software (SW) systems. We can project the ongoing commercial investment will be limited to one operating system for mainframe computation, a family of operating systems clustered around UNIX, and perhaps two or three families of systems on personal

computers. There will also be broad use of standards among those systems, for instance SQL to enable UNIX systems to access mainframe databases, and object-oriented protocols to enable personal computers to access object-structured resources kept on UNIX-based servers.

These interoperability standards will continue to grow in breadth and capabilities. Similarly, features made available in one system will be rapidly replicated and superseded by features provided by a competitor. Even though the pace of change may slow down somewhat, there is little doubt throughout the next 25 years the commercially available software infrastructure will provide the foundation for most DoD and Air Force systems. In mission-critical applications, because of the need for security and trustworthiness, DoD will lag behind the curve with respect to features and cost-performance ratios. This lag should be minimized, so DoD SW availability and its capability to exploit modern hardware does not lag excessively behind adversaries, who may well be willing to proceed with fewer constraints on security and trustworthiness.

Capabilities Appropriate for Government Support Funding

Users need to retain the flexibility to change platforms and use systems composed of hardware and software obtained from multiple vendors, including competitors. Standards conformance should be supported by government, to assure fair and early dissemination of sharable technology.

While NIST has the primary role for standards, there is a role for DoD research to support standards activities that can accelerate the adoption and availability of sharable technology of interest to the military from commercial vendors.

Conforming military subsystems, integrated into the commercially available infrastructure, will provide the basis for future military information and control systems. They will displace the bottom layer of the stovepipes that characterize DoD system architectures and provide the infrastructure for inter-operation of general software development and the global information systems.

Capabilities Requiring Military Investment.

On top of the commercial and national infrastructure will be requirements that require specific military investment if US SW technology is to be maximally effective and superior to the technology of adversaries. Specific capabilities will include:

- 1? Highly robust real-time SW modules for data fusion and transmission.
- 2? Integration of simulation software into military information systems.

Computer Hardware and Architectures

The microprocessors made by a few merchant semiconductor manufacturers will dominate computer hardware designs. Since tens to hundreds of millions of these will be manufactured each year, the low cost of printing so many computers will be irresistible to computer makers.

The microprocessors will be arrayed in networks of various sizes to satisfy product specs: uniprocessors, small multiprocessors, super-scale arrays for major computing power, networks of workstations, and so on. Also scaled to the product design will be networking capability linking the common microprocessors.

Except for stand-alone computers in embedded applications, the slogan "the network is the computer" will become a reality. Computer systems architecture will be largely "plug and play." This implies major changes for the system software, something discussed in another section.

Ultra-large-scale integration of circuits on silicon will follow its historical trend of doubling power per dollar about every 20 months for the next decade. At line widths of one-tenth micron, this remarkable path may end, and other solutions to obtain microprocessor power may have to be found. The solutions may come from new materials (e.g., "bio-organic"), new physics (e.g., atomic-level switching), or new designs (e.g., new approaches to parallelism) or from an entirely new concept not yet known (unlikely).

The wide use of just a few families of microprocessors will lead to the kind of de facto standardization that will make commodity items of all peripheral devices. Huge amounts of on-line secondary storage will be achieved by evolving into parallel-organized databases connected to high bandwidth bitways.

High Assurance Systems

Existing information intensive systems are currently blatantly vulnerable: recent studies have shown the domestic electric power grid, financial systems, and telecommunications infrastructure to have between modest and virtually non-existent protection against information-based attacks. Yet basic techniques exist capable of deterring many of these attacks, and continued development and dissemination of known cryptologic technology will be able to provide very high levels of security to individual systems. Attention should be paid to widespread integration of such technology into Air Force software at all levels (networks, operating systems, and applications). Important attention should also be paid to Air Force *policy* regarding cryptology: in particular, we recommend the Air Force employ a key escrow (or similar) system, in order to ensure that internal use of cryptographic techniques cannot provide an impenetrable wall of privacy to unauthorized action by Air Force personnel.

Difficult problems arise in providing high assurance and survivability for larger-scale distributed systems. A significant body of foundational work exists in fault tolerance for modest scales of distribution, but significant work needs to be done to provide assurance and survivability when potentially every computer in the Air Force will be interconnected. Of particular note will be development of techniques for graceful degradation--the ability of a system to provide appropriately selected partial functionality in the face of unanticipated failures, rather than the all-or-nothing functionality provided by today's approaches to fault tolerance.

Finally, we note with considerable concern while a great deal of attention has been given to the notion of information warfare, there is as yet no notion of rules of engagement in this field. We cannot tell when we are under attack, first because information attacks can be considerably more subtle than physical attacks, but more importantly because we have not yet established any notion of what constitutes a hostile act in cyberspace.

Collaborative Computing

"Groupware" is the label for the notion that computers and information can be used to support business teams, rather than mere individuals (the dominant personal computing paradigm in the last decade). Groupware thus encompasses both the creation of entirely new systems, as well as the pressing into group service systems designed for individual use.

The term "Groupware" was coined in the early 1980s by Peter and Trudy Johnson-Lenz, but groupware systems are yet older. One of the oldest, the Augment system built by Douglas Engelbart at SRI in the 1960s, also happens to be among the most ambitious, incorporating features such as two-way video, group writing, and shared multiple-window screens.

Groupware products are proliferating today, yet the term remains more a concept than a product category in its own right. In the long run "groupware" as a discrete category will disappear entirely, as group-oriented features are incorporated into virtually every product offered in the PC sector.

Groupware as a product category is growing solidly but modestly. The single largest groupware product is Lotus Notes, which is enjoying considerable popularity among corporations, but still has an installed base which is minuscule compared to the total installed base of networked PCs in corporations. Notes itself does not have a bright future, and the features that make it popular will find their way into more generalized environments such as operating systems, advanced data repositories and even Internet browsers and servers.

Groupware will have its largest impact on organizational structures. Even the most casual glance at business history makes it clear that each time a new information

infrastructure becomes available (e.g., railroad, telegraph, telephone) the entities which are ultimately most successful are also the first to reshape their structures in order to gain maximum advantage of the new information conduits. The new networks emerging today are "geodesic" (a term first noted by Peter Huber in the mid-80s in the context of telephone deregulation), that is, global, non-hierarchical and without any central node. It is a safe bet that our organizations will follow suit.

Business Applications

Information technology will change the Air Force way of doing business, thoroughly permeating the Air Force of 2025. From the desktop to the flight line, the business needs of the Air Force will be supported by information appliances.

The business side of Air Force operations will be contracted, not done in house. Outsourcing functions like payroll, personnel and property management will help meet down-sizing and budget constraints.

Information technology will provide the means to commercialize and to more effectively accomplish its remaining business functions. Bandwidth on demand for any application will allow telecommuting from anywhere to anywhere. Coupled with extensive desktop computing power, collaborative planning and telepresence will be the norm. This, EC/EDI, and improvements in our modeling and simulation capabilities will dramatically alter the Air Force procurement and acquisition process. Systems will be created using advanced modeling and simulation and electronic engineering and then they will be "test flown" in a Star Trek- like holodeck before the Air Force buys or builds the first one.

The contract business of the Air Force will join the rest of the corporate world to become another paperless enterprise. Electronic tethers, in the form of personal communication devices, that use voice, video or data communications and intelligent assistants will keep blue-suitors in constant communication with their offices. The bottom-line, the business side of the Air Force will continue to be no different from the business side of the corporate world and COTS software will meet AF needs.

Organization and Education

The revolution in information and IT will profoundly affect the organization and education of the Air Force. As the industrial revolution created entirely new organizations of mass production, the information revolution will lead to new ideas of what organization and education mean. Further, as air power once significantly changed army and navy doctrine and organization, IT power will change the AF even if the primary responsibility for the Information War mission is consigned to another agency. Organization and education will be vital differentiators for the Air Force in a world of commodity technology.

But what are the characteristics of effective organization and education 25 years from now? The beginnings of an answer can be found in organizations that are today riding the IT bow wave. These enterprises are flatter and organized to produce hundreds of niche- targeted products and services. To effectively adapt the Air Force must learn how to strike and defend with hundreds of varied lethal and non lethal weapons from physical ordinance to abstract bits and bytes. A second related characteristic of successful organizations is their attention to front line employees. These workers are empowered with intellectual and informational skills, and the power to act on what they see and observe. Currently, the Air Force is decentralizing the power to act on decisions, but does little *intellectual* and *informational* skill education necessary for sophisticated learning. Instead it tends to rely on training that emphasizes standardization, top down direction, on-again off-again phasing, and physical skill training. These training courses are still useful, but would only be one aspect of a multi-faceted educational system.

New educational processes within this flatter, networked, multi-faceted AF will be more on-going, continuous, and student-centered. Education, defined broadly to include the intellectual and information skills, then will become a vital daily transaction for the organization, in addition to sortie generation. Perhaps contracted mentor-nets involving hundreds of the best educators and thinkers in industry and academe will provide the opportunity for AF "cyber pilots" and "bit jocks" to hone skills, share insights, notice threats, exploit adversary weaknesses, and differentiate our capabilities from hostile organizations.

Organization and education are not distinct, but blended facets of information power are a prerequisite of successful organization. Reinforcing each other they help create a combined system capable of fighting and defending in hundreds of niches. This is similar to how smart terminals within simple networks have replaced large central controlling computer networks.

Recommendations

Future development in information technology will come predominantly from the commercial sector. Military needs are a small part of rapidly growing commercial markets. The key drivers are commercial economies of scale in the production of chips, software packages and fiber bitways and from the importance of standards, de facto or official, that are critical to all information transfer.

However, not everything that the Air Force will need in the future will be available in the commercial marketplace. For those needs that we list below, the Air Force must make long term R&D investments. In some cases they represent added functionality and in others they will be strictly military-unique. These areas will help provide the differentiators so critical to a military future in which both sides have wide access to the same commercial information technology. This is our "focus" message for Air Force IT.

We also have a "defocus" message. We list below areas in which commercial firms will produce products that will be satisfactory for AF needs.

Needed Air Force Investments in long-range R&D (or shared investments with other DOD entities or private companies).

1. Information transfer over the backbone-to-mobile-platform link "the last N miles." Consider intelligent compression, differential updates, high bandwidth directional antennas to create a highly available, minimum bandwidth core.
2. Information fusion comprising both signals and symbolic knowledge.
3. A widely available knowledge web of tens to hundreds of millions of pieces of knowledge. The AF shares in the research costs and develops AF specific knowledge for AF needs.
4. Software architectures that work with AF-specific knowledge, reusable components, safety-critical components, real-time systems, and other military-oriented capabilities.
5. The automatic indexing of images by their semantic meaning in terms of military objectives (intelligent image retrieval).
6. Automatic capture of the rationale for plans during planning activities.
7. Reasoned-action and learned-action agents whose goals are AF-specific.
8. COTS software components and CASE tools enhanced to meet AF combat needs (such as security, survivability, real-time performance, and scalability).
9. Architecture for "just-in-time" information systems and networks "when you need it."
10. Multi-agent planning software.
11. Software that is survivable, displays graceful degradation.
12. Modeling and simulation for training; system design through acquisition; planning and decision making. This will include component interoperation; believable semi-autonomous forces; transition from virtual to actual system acquisition (in a non-proprietary way); validation verification, and accreditation.
13. Augmented reality--the overlaying of synthetic, spatially synchronized, cues and structures on real-time, real-world activity for training and for the maintenance of complex systems.

14. Human-computer interaction capable of sensory-matched control of all UAVs.

15. The technologies and rules of engagement for information warfare.

16. Telepresence, the real-time translation of the human senses and physical dexterity into otherwise inaccessible spaces with possibly "non-human" scaling factors (e.g., very large, very small).

Defocus AF investments from these areas that will be well-handled by the commercial sector:

A. High capacity communications "backbones." global telephone networks; world-wide wireless infrastructure, Internet, ATM.

B. Cryptography routinely embedded in systems

C. Compression (except intelligent compression)

D. Multimedia technologies.

E. Natural Language Understanding, including Speech Understanding.

F. Computer displays

G. Data mediators, request facilitators, information broker software

H. Basic directed-action software agents

I. Software for the "business" functions of the AF: logistics, personnel, finance, etc.

Next Steps:

1. Air Force laboratories must rethink their information technology R&D programs in the light of this New World Vistas report

2. The Air Force should rethink its advanced weapons system design from the info-centric point of view

3. The Air Force should rethink the education, career path, and reward structure for its officers and airmen in light of the IT future projections in this report

4. The Air Force should rethink its acquisition strategy in the light of advanced IT capability

A Sample of Forecasts in Information Technology Important to the Air Force:

1. All cryptographic codes will be unbreakable, but systems may still be breakable.
2. All computer networks and platforms will be scaled from the commodity components of personal computer and workstations.
3. Computers will understand natural language.
4. Bits-per-second in a backbone will be effectively infinite and of near zero cost.
5. Information transfer over the backbone-to-mobile-platform link will remain bandwidth-constrained.
6. End-user programming can harness large bodies of accepted code.
7. Information fusion will comprise both signals and symbolic knowledge.
8. Intelligent programs will carry out "what-to-do" commands instead of "how-to-do-it" commands.
9. Advances in modeling and simulation can enable significant advances in system design, planning, acquisition, training, execution, and reuse.
10. Human-computer interaction will enable sensory-matched control of all UAVs.
11. A profound shift toward information technology must occur in AF education centers and R&D laboratories.

The New Generation University

Dr. Linda Bunnell Shade

Education in the Information Age Conference

April 17-19, 1996

United States Air Force Academy, Colorado

Good morning. It's a pleasure to be with you today. I see that my presentation comes toward the end of a long list of distinguished military and DOD civilian speakers. Let me say that my Colorado colleagues view the Academy as both a leader and partner in our chosen field. Generals Paul Stein and Randy Cubero have worked with us closely to develop collaborative educational initiatives. For example, Colonel Joe Burke, who just introduced me, has come up with some exciting new ideas which should greatly enhance our overall relationship.

My colleagues and I are also following your discussions very closely. For, you see, we Coloradans have a vision of our future as one of the distance education capitals of the world. This vision stems from our history and our current economic environment.

Colorado Springs has had a long and friendly relationship with all of the military services. Since the 1950s DOD has invested heavily in this area as you have built up an extensive complex of air and space headquarters and command and control facilities. This provided the initial incentive for numerous aerospace, computer, and telecommunications companies to locate here.

The influx of additional high technology companies was further influenced by our own inherent geographical and quality of life advantages. These include such things as low cost of living, high quality of lifestyle, great geographical location, excellent air transportation, good public schools, etc. So--as a result--Colorado now has a wide array of aerospace, computer and telecommunications industries and supporting services.

Our "information age" economy requires a supporting educational network. We are in the process of creating an educational infrastructure that both *services* and *takes advantage* of these local high tech industries. This is not an easy task. Yet it is one that will eventually take place across the country, as other regions move deeper into the Information Age.

These developments have also attracted me to this state, and the university. For my career-long goal has been to build a "new generation university," responsive to the evolving educational requirements of our American society. I have reflected upon this topic a lot over the past 35 years as I have helped design higher education responses to changing environments within California, Minnesota, and Colorado.

So--what I'd like to discuss with you today are the following questions:

1. How is American society changing as we enter the Information Age and how has this affected higher education?
2. What will our new generation of universities look like, and what will their mission and operating principles be?
3. What are the challenges that face us in this new era, and what do we need to do to insure our continuing relevance, viability, and vitality?

How is our society changing and how is this affecting higher education?

As time is short, I will focus my analysis on the three most important changes: workplace requirements, public perceptions and expectations, and demographics.

Our American workplace demands and education and training needs are changing dramatically, which impacts both our student population as well as our curriculum. So more students will be spending more time on our campuses receiving additional education and training.

In addition, our educational outcomes and our curriculum need revision. Recent American Council on Education reports demonstrate this. Although today's hires are as good or better academically than in previous years, they are deficient in interpersonal relations and communications skills, teamwork, quantification skills, and the capacity to adapt to rapid change. It's great to see that your Academy educational outcomes address these skills.

ACE further noted that business CEOs feel that higher education:

- is not taking the needs of the private sector seriously,
- is unable to respond quickly,
- is trapped in a discipline-bound view of knowledge, and
- there is little integration among disciplinary courses.

Finally, ACE observed that the greater the amount of interaction between the university and industry, the more responsive the curriculum. However, interaction varied widely across a university. Consequently, the effectiveness of our programs in meeting corporate needs vary widely as well.

Dramatic change can also be observed in public perceptions and expectations of higher education. We find ourselves in a political environment where more people are questioning the role and cost of government, and where there is a growing public desire to reduce rather than raise taxes.

An interesting point here is that our political climate is partially shaped by the large number of military retirees in Colorado. This is also a result of the strong DOD presence I mentioned earlier. An unanticipated outcome is that many of these retirees just don't like to pay taxes.

Plus, education is a social service that, within Colorado at least, consumes a large part of our discretionary public spending. Therefore, any new or expanding social service requirements, such as prison and correctional costs, will affect the resources available for education.

We also find growing public concerns about the effectiveness and efficiency of higher education. Therefore, an increasingly popular public attitude is that we in higher education need to be held more accountable.

Finally, we are seeing large-scale demographic changes in both the diversity and size of our population. Our nation faces an increasingly diversified ethnic make-up with growing percentages of blacks, Asians, and Hispanics. A recent Census Bureau report predicts that by the middle of the next century, our student population will be 45 percent white, 25 percent Hispanic, 18 percent black, 9 percent Asian-American, and 3 percent American Indian or a racial mixture.

Increasing ethnic, gender, and sexual orientation differences within our society and our work force generate new educational outcomes not historically mandated within higher education. For example, we need to provide our students with a better understanding and respect for diversity, and the ability to work with diverse groups of people.

We are also experiencing a significant increase in the number of high schools graduates who will soon enter our colleges and universities, and a decline in these numbers in other states. This is in addition to those non-traditional students returning to campus for job-related skills.

Our CU Master Plan projects that in the next 10 years our four campus system will experience a 24% increase in overall enrollment, and a 30% increase in resident enrollment. This represents almost 8,500 more resident students than we currently have. This trend is common throughout the Western United States.

On my own campus, we are seeing more than a 20% increase in freshman applications, and a 15% increase in the overall application rate. Obviously there are other factors driving this increase, such as new campus housing, an effective student support program, and a better recruiting effort. However, we know that our campus will be much different within a few years.

What this means budget-wise is that within the next 10 years, the University of Colorado system will need an additional \$320 million in new facilities and an additional

\$70.5 million dollars per year in operating costs. Yet--to make my point bluntly--we do not anticipate that proportional increases in state and federal funds will be available. The bottom line--we won't have sufficient money or facilities to educate future students in the fashion we now do.

In summary, we in higher education are being challenged to do more with less: to maintain quality, expand educational outcomes, provide a more vocational emphasis, and educate more students at less cost per student. In addition, we are being asked to provide greater community support. These factors have forced us to review our basic mission and operating principles, and to develop what I call a "new generation university."

What will these new generation universities look like?

First, let me say that within our state alone, we have numerous types of institutions. We have our private colleges, our major state research institution at Boulder, and our land grant colleges located within our sparsely populated rural areas. Finally we have those universities such as mine which were specifically designed to meet the needs of an expanding metropolitan area. Each will evolve in its own unique ways.

It is too early to give a complete report on how each of these will change. But, we are already seeing the basic outlines at innovative universities, such as the University of Houston, the University of Central Florida in Orlando, and the University of California at Irvine.

Perhaps the newest and most dramatic experiment is taking place at California State University at Monterey. This is a new university, being developed on the former site of Fort Ord. This campus is creating a whole new curriculum based upon educational outcomes versus prescribed courses, organized around inter-disciplinary centers versus academic departments, and built upon a cooperative-entrepreneurial operating philosophy.

Based upon my own thoughts and research, my experiences within four separate university systems, and the reports coming in from the universities mentioned above, I believe that the "new generation university" will be based upon the following four operating principles:

- a greater emphasis on undergraduate education and student support;
- a more flexible curriculum and delivery systems which provide greater access and convenience to both degree-seekers and lifelong learners;
- an increased emphasis on applied research that supports economic and social development within local communities; and
- a greater commitment to public service through partnerships.

Let me spend a few moments providing you with specific examples of how we are attempting to achieve these principles at my own campus.

Principle #1 - Undergraduate Education and Student Support

We have established a Student Success Initiative to better meet the needs of our student body. As a result, we now have a streamlined, one-stop, student advising process; a semester-long academic assistance program for new students, and separate academic help centers for writing, oral communications, math, and science. This has resulted in significantly improved student academic performance, and a decline in student drop outs. It is a reason why we are seeing more student applications. Prospective students--both traditional and non-traditional--expect this support.

Our students voted to assess themselves a \$10 per semester fee to support revenue bonds to construct a new family support center, scheduled to open next Fall. This will help meet the needs of our non-traditional students, who now form the majority of our student body.

As you might guess, I can't change my university overnight. I have a list of things that still need to be done. As Chancellor, I feel like a mother giving birth to a child - my next generation university. However, it's going to take time for us to create this new institution.

Meanwhile, if we are to survive as a vibrant institution, other initiatives must be taken. Each will require Board of Regent and State Legislature involvement. These include:

- We will enhance our multicultural awareness and global perspective programs. I have already appointed an Assistant Vice Chancellor for Academic and Multicultural Affairs, and have a task force working on ways to internationalize our curriculum and expand our international study opportunities for both students and faculty.

- We will expand our student support to include a more effective career advising, internship, and placement office. Experiential learning is becoming a more effective tool to help our students get jobs.

- We will develop a better curriculum review process to meet the changing needs of our society. To be honest with you, I've listed this last, because it will be the most difficult to accomplish.

Principle #2 - Flexible Curriculum and Delivery Systems

Growing numbers of students, emerging information technologies, and the opportunity to work with local telecommunications companies have been great incentives for us to move into the world of distance education.

For several years we have been involved in Jones Intercable's Mind Extension University. In fact, Professor Barb Swaby from our faculty is now a TV celebrity with her 92 hours of broadcast instruction, in support of an award winning program entitled *Journey into Literacy*.

More recently, in January, we announced our partnership with Mind Extension University to establish a Joint Master's Degree in the areas of Public Administration and Business Administration. This program will be offered world-wide using Jones' extensive telecommunications facilities.

This new program will allow students around the world better access to our educational programs. It will also enhance our faculty understanding and skills to better integrate video programming, computerized instruction, and the internet.

My university is not the only one in the state interested in this type of delivery system. Last November, at the Western State Governors' meeting, Colorado Governor Roy Romer spearheaded an initiative to create a Virtual University of the West. This could offer standardized general education courses using advanced telecommunications to all states in the West.

Our requirements in the area of technology are numerous. Fortunately, we have received state funding to build a large new classroom building to meet the needs of our expanding enrollment. This comes with a technology allowance which will allow us to procure modern classroom technology. However, a problem I face is that it is also impossible to gain additional funding from my legislature to retrofit existing classrooms, and to establish an appropriate replacement and upgrade cycle for existing equipment.

Finally we desperately need a student and faculty technology support center, similar to the ones you have here at the Academy. This is also extremely expensive, yet essential to more fully exploit emerging technologies.

Principle #3 - More Applied and Community Relevant Research

Our efforts to create stronger research ties to specific community economic and social needs are numerous. The El Pomar Foundation has been instrumental in helping us in this vital area. El Pomar is the largest foundation in the West, and was founded by Spencer Penrose in 1937. During his lifetime, he made his profits from mining and the Broadmoor Hotel. Perhaps the most visible accomplishments are our three recently established endowed chairs devoted to this activity. Plus we established on campus the Colorado Institute for Technology Transfer and Implementation (CITTI), which searches out new and innovative joint research projects between the campus faculty and local business.

Principle #4 - Community Partnerships

The community requirements that drove our establishment as a university in 1965 continue to drive us to develop strong relationships with local industry. In fact, we have just hired astronaut and Academy graduate Ron Sega to be the Dean of our Engineering School. Ron's major emphasis will be the further integration of our University of Colorado engineering education and research infrastructure with local industries.

As an aside, Ron is a good example of the linkage between our military and civilian education organizations. He is an Air Force Academy graduate (Class of 1974) who returned to the Academy as a faculty member. He then earned his Ph.D. right here at the University of Colorado Colorado Springs. In fact, Ron was our first Ph.D. graduate in the field of Electrical Engineering.

We have also joined forces with our Chamber of Commerce, local school districts, and technology corporations, such as Apple and MCI to create an exciting new educational technology project, called LINC - "Learning in the Next Century." This project brings together business and educational resources to learn how to better exploit emerging educational technologies.

Finally, we are currently engaged in a joint campus-community strategic planning effort to determine ways to better serve the needs of our Colorado Springs community. This will give us a much better understanding of our "new generation university" mission and structure.

So - I hope that you have some idea of what the new generation university will look like, and our own campus efforts to get there.

Let's now turn to our third and final question:

Question 3 - What are the principal challenges we face and what initiatives should we undertake to get us there sooner.

I could talk about this for the rest of your conference. For now let me describe what I believe are our two greatest challenges:

- inadequate governmental and public support for higher education, and
- inappropriate campus governance systems.

Without appropriate levels of public support and financing, we cannot maintain an educational infrastructure capable of meeting the needs of the 21st Century. We need to develop a similar sense of vision as that created by John Kennedy in the early 1960s. He convinced our nation that space exploration and the achievement of manned space

flight were such noble endeavors that we were willing to contribute the resources necessary to create NASA and the various space launch initiatives.

Our financial problem at my campus is made more difficult because we are a relatively new and fast growing urban university which is dealing in a university system with a strong degree of favoritism toward its oldest campus. This is an example of how difficult it is for us to make rapidly adjust our vision and resources to meet changing community needs. *It's time we in higher education look through a window to see the future rather than staring at the mirror.*

Furthermore, we need to create new human systems to help us fully exploit emerging technologies and to keep up with the rapidly changing educational requirements of our society. Examples of systems needing revision include: governance, student support, and student tuition financing.

In the interest of time, let me just focus on governance systems. Our federal and state regulatory systems must be revamped to allow a de-centralized process designed for speed and effectiveness. At the federal level, we desperately need new financial aid mechanisms for our needy students. At the state level, we need a better academic program review process.

Our state governing boards need to be provided with more clear-cut roles and responsibilities, and our board selection system must insure that we have highly trained and experienced members. In the state of Colorado, this includes both the Colorado Commission on Higher Education and the CU Board of Regents.

Finally, our campus internal governance systems need to be re-vamped. Our current system, which purports to emphasize consultation and shared decision making, does not attract faculty participation, is too conservative in its attitudes toward change, and moves too slow to accommodate the rapidly changing times ahead. David Breneman, noted Harvard and UVA Education Professor and former university president, notes that our current system "seems poorly suited to the sorts of wrenching changes that lie ahead."

Richard Mahony, CEO of Monsanto Corporation, summarized our predicament as follows: "I had a dream the other night, and a nightmare... The nightmare was that I dreamed I was the CEO of Monsanto--and had to run the corporation like a university."

As I have discussed, our challenges are substantial. Therefore, I would like to suggest one final initiative - to identify and prepare our next generation of leaders to lead us as we move into the next educational generation. Therefore, it is appropriate for this conference to take place here at the Air Force Academy. For leadership is what you are all about.

I know that your specific area of expertise is military leadership, but the components of leadership in this new era are very similar for all elements of society. In

fact, let me further propose that the educational requirements of citizenship in the Information Age are the same as for a military officer in the Information Age.

As evidence, I again note that the superb list of Academy educational outcomes developed by General Cubero and his faculty are almost an exact replica of the list included in the ACE report.

Our educational leaders, just like our military leaders, must also possess absolute integrity, a strong sense of service and commitment, competency, courage, and a "risk taking" attitude.

So my challenge to all of us in leadership positions is to spend time and energy in the development of our replacements. They will be the key to the success of future generations of universities.

Now--if you will let me--I would like to spend my final moments at this platform addressing the question of how this discussion relates to service academies in general, and the Air Force Academy in particular.

Within our civilian colleges and universities, we are beginning to see the importance of greater levels of cooperation. We are beginning to see the importance of closer linkages with our K-12 and community college systems. We are beginning to see the need for more comprehensive interactions between the academic and business communities.

I would suggest to you that we also need a greater level of cooperation between our civilian and military educational institutions, including our service academies, professional service schools, and other DOD educational and training organizations. *General Cubero and I are currently looking at ways in which we can cooperate more closely, especially in the areas of faculty development, technology integration, and internationalizing our curricula.* I challenge you to use this conference as a stepping stone to further cooperative endeavors in the future. I'd like to help.

There's No Bits Like Show Bits

Mr. Bran Ferren

Education in the Information Age Conference

April 17-19, 1996

United States Air Force Academy, Colorado

Okay, brace yourselves. You're going to get a very state-of-the-art experience today. It's completely nonlinear, has no single point, and no particular beginning or end. It's a thirty minute version of what's normally a two hour talk. Basically, I plan to just ramble on 'till someone stops me. If there *is* a message it's about why one of our earliest technologies, storytelling, is not just alive and well today, but will be the key to success in the Information Age. And, how aspects of both the art and science of storytelling may be essential to *your* success, *especially* if you happen to be an engineer, pilot or educator.

After I agreed to give this talk, the very next question was: "Do you have audiovisual material?" I said yes. They then said, "Will you send it along in advance so we can make sure we can play it?" I said, "No need, I *am* the audiovisual material." They weren't impressed. (Which is why right about now I really want to say, "May I have the first slide, please?" just to see that great look of panic in the eyes of the AV staff, but I wouldn't do something like that.)

Sometime later (still recovering from the idea that the Disney guy wouldn't have any AV stuff), they asked if I could demonstrate some state-of-the-art, gee-whiz interactive technology--because, interestingly enough, the entertainment industry is really driving much of the interactive business these days--so I agreed. What I'm going to show you now is an example of a high performance interactive system that combines real time multispectral vision (with the ability to do human gesture recognition), continuous speech recognition (including limited multilingual capability), multiaxis haptics, sensor fusion, database fusion, common sense and contextual parsing, and unique fuzzy-logic information correlation capability. This is all tied together with a large neural net (which is still pretty much as good as it gets), and has the ability to operate complex external systems and explore the environment through multiple precision effectors. This system is as good as interactivity gets.

It's me.

It's important you remember this, because *we humans* are the best interactive technology developed to date. A masterpiece of "wet" systems engineering. By comparison, this interactive electronic stuff is totally primitive. *You* know when you're using your computer, but *it* doesn't have a clue that you even exist. If you are involved with the design or use of today's primitive man/machine (or person/machine) interfaces, it's important to remember that they all will be used and evaluated exclusively by magnificently sophisticated biomechanical interactive systems called people. And we are

very persnickety users. As a designer, it's important to know your audience and your critics. As an engineer, it's important to know both your users and the folks who will execute your plans. And as a pilot, you'd better hope that the designers and engineers who created your aircraft anticipated *your* needs well.

Before we go on, I need to give you a little disclaimer. I'm a story person. I think, live and breathe story. People who come from my world--I have a split art and science background--basically think that story means just about everything. We believe that most anything one can do in this world, even including the role of the modern warfighter, can be done better the more you know about storytelling. You should remember this because it will give you a better sense of where I'm coming from.

So let's go back to my early career in electronic interactivity. I was hired in 1985 as a consultant to the Canadian Government. They were doing a world's fair called Expo '86 (which tells you a bit about the long-term planning that goes into some of these events!) They wanted this fair to be the cat's meow of interactivity.

Interactivity was the world's fair buzz-phrase-de-jour in 1985. (Some places it still is.) In my experience, you can't get a project funded without a good buzz word or at least a spiffy acronym. This seems to apply equally to world's fairs, industry, education, or the DOD. These days in personal computing it's Interactive Multimedia. In the DOD/R&D world it used to be artificial intelligence [AI], or expert systems, or robotic vision, or optical data processing, or sensor fusion, or smart rocks, or brilliant pebbles. Depending upon what you do and where you get your funding, if your project doesn't have those words in it, you probably won't get it off the ground. Has anyone tried Genius Sand, or Prodigal Dust? Some of these terms go out of fashion quickly (like AI) and are now to be avoided at all costs. Because everybody knows that AI is old hat, doesn't work and is a waste of time, for now. Even if you do have a great AI project, you'd better call it something else if you want to get today's research money. Surprisingly, the term "Interactive" is still hot, especially in education.

The Canadians wanted to do a project called the Future Choice Theater. I discovered that the purpose of this exhibit was to bring together people from all over the world, show them the beginning of a film that posed pithy questions about the trajectory of our society, and then let them *interactively* vote (by pushing buttons attached to their seats) to determine how the story (and our future) will end. (thereby giving each audience a unique experience based upon the sum of their votes).

I was hired initially, I thought, to be the creative force behind the entire project. As with most Canadian World's Fairs, it turned out that they preferred to have a Canadian creative force (something about government funded projects and the fragility of national pride). Nonetheless, they asked if I could solve the one remaining technical problem, namely; how to hook up all those little push buttons on each and every seat. At which point I thought, "Okay, having dropped out of MIT, I should be qualified to do that." I said, "No problem! I'm your man."

Given a few hours of thought that evening, I came back the next day with my official recommendations, which were:

- 1) Install all the push buttons.
- 2) Don't hook any of them up.
- 3) At the moment in the story when we ask the audience to push their button of choice, flash a few numbers on the screen, wait a moment, and then run any ending you want, picked at random.

They accused me of having a bad attitude.

The funny thing is: I was serious. I attempted to point out to them in a nice way that their scenario was flawed. It was basically a bad idea. Their project was like some demented Turing test for the validity of an interactive experience. As they had designed it, there was no way that anyone in the audience could ever know if the buttons were really connected or not. This is what I affectionately call dumb interactivity. When you vote, and the whole audience gets the ending *you* selected, it's because you're with a bunch of clever and incisive people who are really with it and get it (just like you do). If, heaven forbid, you don't get the ending you wanted, it's because you're surrounded by a bunch of uncultured yahoo foreigners who are both completely clueless and obviously don't understand where our civilization is going. In my humble opinion, this kind of interactivity had no real value beyond perhaps being a parlor trick. It adds nothing of any real value. A waste of time and push buttons.

This is a classic example of a *Solution in search of a Problem*. Unfortunately, in the world of technology, these are not uncommon.

High definition television (HDTV) comes to mind. Do any of you here have HDTV, that miracle technology which has had billions invested in development so far (and has been "just around the corner" for over twenty years)? Besides, if you had an HDTV set today, what would you watch on it? *How many of you who are dissatisfied with conventional televisions think the problem is the number of horizontal scanning lines, rather than the lines of dialogue spoken by the actors? If so, you are watching different television than I am.*

I've just finished seeing a TV show and said, "Wow, that was really great, exciting and thrilling, but if it only had another 472 horizontal scanning lines, it really would have really changed my life!" HDTV, as proposed over the past few decades, has been another solution in search of a problem.

This is an example of how technical resolution alone isn't enough to describe how most of us couch potatoes think TV could be improved to add more value to our lives. Crass as it may seem, most of us measure the value of any new product by how well it can compete for our two most valuable possessions: Time and Money. When you're a kid, money seems like the big kahuna. But, about ten minutes before you drop dead, *time*

takes on a whole new meaning. For most people the total amount of time or money that they will ever have is pretty predictable. The successful consumer products have always been those that can effectively compete for either or both. This has been true since the beginning of time and money.

So what's wrong with this (you should excuse the expression) picture? We're basically talking about an audio visual display system--and isn't more resolution always better, and by extension, worth paying more for? The truth is that technical performance is only one part of what's needed to describe how we living, breathing, interactive humans perceive the Quality of a display system. This is because--unless one is unusually partial to test patterns--most of us watch TV shows on television. TV shows are usually stories of one form or another. Sitcoms, news, weather, or stock prices are all about storytelling. We almost never see the display system working without the story content that is produced to be shown on it. And the measure of how we experience these stories cannot be adequately expressed by quantitative means alone. The content and how well the story is told usually matter as much, if not more.

Most engineers are experts in dealing with technical resolution. They are entirely comfortable with this kind of purely quantitative approach. Given enough time and money (and providing you don't butt your head against some limit based in physics), they will deliver the resolution you need for any clearly stated set of requirements. It doesn't matter if the image is on a movie theater screen, computer terminal or the Heads Up Display (HUD) in an F-16--give them the numbers and they will deliver the appropriate performance.

In many AV systems, however, (like TV, movies, WWW, etc.) there are *qualitative* attributes beyond the spatial, chromatic and temporal resolution that are critical to how well they can communicate complex ideas to viewers. These attributes are often imbedded in the content. I am proposing that there is another type of resolution. It is a qualitative measure, just the kind of thing that makes many engineers and scientists nervous. I'm calling it Emotional Resolution, because I haven't been able to find anything better to call it which attempts to speak to this issue. Professional storytellers, like movie directors, photographers, and writers, are expert in understanding and manipulating this other kind of resolution.

What do I mean by content? In the multimedia world these days--which incidentally is a world filled with much nonsense (because it has *lots* of solutions in search of problems)--the subject comes up regularly at major conferences. I speak at a fair number of them. There's probably one happening every 11 hours or so, which last I heard coincides with the rate at which McDonald's are being opened around the world. If you think *you* have a logistics problem, try training people how to flip burgers at that rate of expansion.

People go to conferences to discover or reveal the killer app [application]. You may have a different definition of killer app, but in the multimedia business it's

something like Myst, a product that (even if it doesn't change the world), will make its creators very rich.

I've followed the history of killer apps. I think the last killer app before Myst was the Gutenberg Bible and, presumably, there's another one coming up sometime soon. Inevitably at each conference someone gets up and announces that they have the secret of the next *huge* killer app. Suddenly, the room gets very quiet, a hush falls over the crowd, lots of Japanese tape recorders are thrust up into the air towards the speaker who breathes out a single word: "Content". The Killer App for Multimedia is going to be something with great *content*!

Sometimes there's a round of applause; some people look impressed. Other speakers who had announced earlier that it's really about 3D graphics, or sound, or distributed game icons, look annoyed and occasionally confused. Someone actually said that content is what it's going to be all about. This is a great example of how people tend to lose all ability to exercise common sense when talking about technology. *Now, try going to a booksellers' conference and telling them that you figured out the secret of publishing is content.*

It's not the binding, it's not the serifs, the size of the type, it's not the way you kern the letters, it's not the color of the background paper; it's content. And they'll look at you like you're some sort of idiot. Of course it's about content. What else would it be? Every school kid knows this.

But say it in the world of multimedia, and you're considered to be the great soothsayer predicting the coming "next wave" of multimedia. The sad fact is that virtually everything you have seen in multimedia to date is junk. It's awful; it's bad; the CD-ROM is, again, a solution in search of a problem. No one asked for a CD-ROM. In the audio business it was developed as a way to provide cost-effective digital storage, and then someone said, "Oh, I guess bits are bits; and so we can put data on it, so here you have it, a new medium. You know now that we can put a little half a billion bits of data on it. You computer people go figure out something to do with it". I guarantee you that in fifty years you won't even be able to find a machine that can read a CD-ROM outside of a museum. You can still read Gutenberg's stuff as well as the day it was published.

In the meantime, we've got people (including me) using junky computers with junky disk drives and junky software trying to make this multimedia thing into something important. Now, I happen to think that multimedia actually will, in fact, become a critical part of the educational process and everything else, and it's important that we get started now, so we can learn what *not* to do.

But you have to realize that it's still all junk. Because if you don't, you're going to miss the point, and you're going to stay in the Stone Age of the Information Age. You have to have high standards or it will never get better and instead just fade away. If you don't have standards, you won't push it to the next stage. There's a reason we don't fight

wars in biplanes anymore. It's because the pioneers of aviation didn't settle for junk they were given and kept pushing for better ideas and technology.

But let's get back to this concept of emotional resolution. What do I mean by it? And what's the different between conventional technical resolution and the emotional variety? First let's talk about conventional technical resolution. Let's say we're talking about a visual display application like putting images on a screen. Find an engineer and ask them to describe the performance characteristics of an example of this kind of system. They would tell you that it's really pretty straightforward. If it's digital, it's about how many pixels there are – an expression of the horizontal and vertical spatial resolution. Then the range of brightness (luminance and gray scale linearity) and color space capability (chrominance) that it can handle. There may be some other details like viewing angle or the ability to be seen in the dark (or full sunlight). There is its temporal resolution, how quickly it can update the image. These requirements can vary enormously with the application. If for example we're talking about a home TV, color quality (especially of skin tones) is important but the brightness spec isn't terribly demanding. On the other hand, an EW (electronic warfare) display on a fighter aircraft needs very high temporal resolution (because things can happen really quickly) and very high brightness and contrast (so you can read it clearly with direct sunlight on the screen).

So is that it? With spatial, chromatic, and temporal resolution we've basically said it all, right? Well, no, we haven't. While these metrics pretty much nail a big portion of the tech stuff, so far I've ignored this whole issue of emotional resolution. And it matters a lot. It comes into play when you look at the performance of the display and the viewer, taken as a unit. It's like that tree falling in the forest. How successfully did the display communicate the information content shown on it? Obviously it's a problem if they couldn't see the image clearly enough to read printed text or it wasn't capable of reproducing the color of an object closely enough to be useful (like seeing the difference between red and green on a traffic light). But in real life, the examples are often much more subtle. With apologies to McLuhan, the idea behind emotional resolution attempts to embrace how effectively a given medium can communicate the desired message. So how can such a subtle effect be that important and affect the performance of my display system without showing up in the resolution specifications? Well, sometimes it does show up, but the delta in technical measurement can't be directly correlated to the observed result.

Let me give you some examples. And I guarantee it's going to be hard for some of you of the engineering persuasion to accept some of this "soft and fuzzy" stuff. (Incidentally, as I mentioned when I started, this talk includes a free demonstration of interactive technology, so any of you who disagree with this or have something to say, just throw something or send up a flare or something. I will notice it, and we can talk about it.)

If I think back to television (which is a display system), what are the things I watched that changed my life forever? I can easily recall a few of them. I can remember

one summer as a young boy, I was in Norway--I'm not Norwegian, but we were on vacation in Norway. We went into a bar or a pub or something. Everyone in this place was transfixed watching a television over in the corner of the bar. It was a black and white television, the picture was awful. It was sort of a blob of fuzzy light of moving across the screen. I heard about a dozen words, that forever changed my life. Those words were "One small step for *an, one giant@ *^ep _or mankind". I will never forget those words until the day I die. (Who knows - maybe after.)

Now then, the quality of the imagery I saw as Neil Armstrong was moving across the screen could have been done better in my room with a flashlight and a bed sheet than what I saw being sent back live from the moon by the time it got to the pub in Norway. I recall it said, "Live from the moon" at the bottom.

I had to wait until Walter Cronkite told me what the words were, because with the static and Norwegian overdubbing you couldn't understand anything that was being said, and yet I remember it vividly to this day. This had extremely high emotional resolution even though the technical quality of the data link was awful. Many of the words couldn't be understood, but it doesn't matter. My imagination aided by a great storyteller, Mr. Cronkite, filled in the gaps. How many of you were of the age where you remember that event, and still remember every moment?

Another televised event which I remember vividly was when the President of the United States, John Fitzgerald Kennedy, was assassinated. I was a kid in school, I didn't know what was going on, I didn't know what was happening, but I knew from that moment on that something about my life, and the life of our country, had changed. It changed permanently and irrevocably, and I'll never forget how it felt. Again, the visual resolution wasn't great, but coupled with the comprehension of what had happened gave me all the detail I needed (or could handle).

Take a more recent event like the explosion of Challenger. I can never watch a Shuttle launch again without thinking about that moment. The technical resolution of those TV frames were so-so, nothing to write home about, but because of the story behind them, they had extraordinary emotional resolution.

This is what emotional resolution is about. The process of communicating ideas to people goes far beyond technical resolution. This is not a subtle effect, it's a critical effect, and it's one I would argue that we have to understand if we're going to approach the entire subject of education or communication with electronic systems.

And with due deference to many in our audience today, how might the emotional resolution of a display matter to a combat pilot reacting to the picture on his or her HUD? Simple: establish the convention that red striped icons represent *possibly* validated well trained hostile enemies, with known evil intent, who *might* find it desirable to explosively transform you into a kit of parts. The solid red ones are validated ready-to-kill-you enemies. But the red striped ones are striped just based upon educated hearsay from

others whose opinion you have reason to respect. (All the other colored icons are either friendly, unarmed, incompetent, or otherwise benign.) I don't care that your electronic warfare system says that their radar is off, or that they are too far away to do you any harm. I don't even care that the threat information may be soft and fuzzy (based upon the gut feeling of another pilot) or even wrong. I guarantee you that seeing little red striped cartoons on your display will get your attention in one big hurry. You aren't reacting to hard facts. You're reacting to the *story* that you believe could be behind that little striped icon. The back story (as writers would call it) matters to you, even if you don't fully understand it. This is why most military commanders I've spoken to think warfighting is as much of an art as it is a science. The history of their art and professional experience is often their way of talking about storytelling.

Let's move on and talk about this Internet thing we're all hearing so much about.

Our speaker this morning talked about the NII. The National Information Infrastructure, recently renamed by some the GII, for Global Information Infrastructure. I've been referring to it as the III, International Information Infrastructure, because I think "AI YI YI" is a better description of what's really going on.

We're told the Internet is going to change our lives, and that developments like Virtual Reality (VR) and Augmented Reality are going to *really* change our lives once wideband network connectivity gets real. Why should you believe any of this? *Why do you think that the World Wide Web is going to have an any more of a profound effect on our lives (or professional careers) than Citizens Band (CB) radio did (which was, after all, another communications tool for the people); quadraphonic sound, for that matter?* Remember quadraphonic sound? It lasted for about two years at best.

CB radio was growing like crazy ten years ago. A billion dollar business to be. You could even order cars with CBs in them as factory equipment. Then it imploded. When was the last time you saw or used a CB? Why do you think the Net is different? How many of you *do* think it's different? [about one third of the audience raise their hands.] Do you think the whole World Wide Web is fundamentally important? How many do? [About three quarters of the audience now raise their hands.] How many don't? Okay. The majority do...but why?

How many of you are on the World Wide Web? I'd like to talk about this, because I think that what's going on with interactive networks (of which the WWW is an early primitive subset) and VR is not *just* going to last, but will probably prove to be *the most important technologies developed to date by mankind*. They will permanently and irrevocably change the lives of everyone in this room (if you live for at least twenty more years). I absolutely believe this. If you ask exactly how it will do this and want specifics, I'll first make something up, and then confess that I'm pretty clueless. I really have no idea about the details. At least I'm honest about it.

But I *can* tell you why I believe it will be so important. We all have the luxury of being able to look back into history for hints. History gives us a way of looking at those things that proved to be important in the past and of using them to guide our vision of the future. For better or worse, people's fundamental needs have actually changed very little over the years.

Let's look back through recorded history at what technologies permanently changed the trajectory of civilization. Let's say that this is your basic criteria: it had to have changed the course of civilization or society. What would you say was the first big technology that had that kind of impact? [From the audience: Printing, The Wheel, Fire, Writing, The Nail, Speech.]

How about language? We spent about a million and a half years as Homo Sapiens, sort of messing around, grunting and groaning, living, reproducing, killing each other, doing a whole bunch of fun things like that. But before language, there was no such thing as society, because there was no sophisticated method for people to communicate en masse and collaborate with each other.

Now, if you have two people that grew up together, they would automatically learn to communicate with each other. Only problem is, they couldn't interoperate with any other people who grew up somewhere else. And so the first big communication standards and protocol battle took place and was eventually (self-referentially) called language. *Language: the gradual development of standardized speech and the subsequent (or parallel) evolution of a technology called Storytelling made it possible to organize and communicate complex ideas in a way that is both generally comprehensible and memorable.* So I guess you could say that Storytelling is *really* the world's oldest profession.

After a million or so years of not doing much other than grunting, groaning and surviving--and understand grunting and groaning is useful to accomplish a certain range of things in one's life; but at a certain point, if you want to build a society, you need to get beyond that--these two technologies changed the world.

So what came after language? Someone said it earlier: Writing. This was another big one, and lest we forget, writing is not an obvious extension of spoken language. The first writing was a series of pictograms that told a story. The abstraction of words and writing as we now know it just wasn't obvious and took a long time to catch on. It's why *recorded* history is a comparatively recent phenomena in our past. It required a notion of icons, alphabets, sentence structure, page layout, and a whole bunch of other things that are not natural to people just being folks. If you just went through life speaking, you probably wouldn't come to writing as a natural extension of that process.

Why *did* we come to invent it? Who decided that we needed writing? Did some primal government agency *speak* a requirement for it? We invented writing because it got a little tiresome that every time a Fred or Ethel dropped dead, the recipe for

something like fire disappeared, and we had to wait a few hundred years to rediscover it. So the idea of being able to take story ideas that were originally communicated orally by fable and myth and put them into a more permanent (written) form became critical to keep society moving forward. Even then we realized that education was important. However, originally these texts were kept secret and far away from society at large. Even then people realized how powerful books could be. They still are. That's why at times of stress some people feel compelled to burn them for the public good.

I think it's important to mention that other critical technology again at this point: Storytelling. It's hard to say if the storytelling form was invented (or we're just wired to think that way) but without the story form, most people find complex ideas virtually impossible to remember. Besides, I would bet that all of *your* great teachers were also great storytellers.

What was next? [From the audience; Agriculture, Electricity, Steam, Time?] Time? Was that invented? Okay; time *keeping* was a useful skill (especially to determine longitude at sea), but wasn't it largely predetermined for us by celestial and other natural rhythms? So we sort of came up with a definitional concept that got more specific after numbers came into use. But what else? Some big pivotal inventions?

[From the audience: the printing press.] Good, the printing press. Who invented the printing press? [From the audience; Gutenberg.] The printing press was invented by the Chinese several hundred years before Gutenberg. But apparently, if you want to be remembered for an invention in our textbooks, it helps to be male and white and European. But he did apparently invent a commercially practical way to print with precision metal type, so let's give him his due.

So what was Gutenberg trying to do, change the world? Not likely. He probably got into this because he was looking for the Killer Application (Killer App.) His publishing business was slow and he needed something to invigorate sales. He thought he figured it out: cheap bibles. If he could make them faster, cheaper and better (or at least faster and cheaper) with this new technology, he could make a killing.

Anyway, Gutenberg's business troubles were hardly over with his new invention. He probably had terrible union problems, the monks were up in arms, etc., etc. (This was clearly the work of the devil and was going to put them all out of business, and besides, the quality wasn't as good as the-real-thing: no civilized reader would accept it. Does any of this sound familiar when any new media is discussed?) The fact is that the printing press certainly did change the world. None the less, Gutenberg died penniless and was clueless as to what the real impact of his technology would be. It was not about lowering the cost of Bibles. The whole Bible thing had a comparatively minor effect. *What changed the world was the introduction of a technology that made it more efficient to tell stories to larger numbers of people.*

Let's move forward in time. What would you say is the next big technology that changed the world or the way society evolved? [From the audience: the automobile, television, the telephone.] The telephone sounds like a good world changing candidate. Who invented the telephone? [From the audience: Alexander Graham Bell.] Bell did not invent the telephone as we know it. He just got the core patent for it. Elijah Gray invented the telephone. Bell filed for his patent somewhere between four hours and two days earlier (to date the most valuable patent award in history). But Bell was apparently being funded by an institute for the deaf, and he thought this invention was a way to help people who were hard of hearing to better communicate with each other. The fact is the telephone has been, to people who are deaf, one of the most culturally isolating devices ever developed. The phone changed society to make much commerce and daily social interaction possible without the need for face to face contact. Who do you think this new way of living excluded? The deaf and hard of hearing, among others.

Bell was also clearly clueless as to what the impact of his invention would be, and it actually took a long period of time for people to adopt and learn to use a telephone. Having one telephone is about as useful as one tube of epoxy. You sort of have to wait until someone else has a telephone to call, and that took some time. At first many people proposed that the highest use of this new device would be to remotely listen to concerts and plays.

Also there was nothing intuitive about how you were supposed to operate it once it was installed in your life. People had to be educated and new conventions established. Early on many calls would be failures. Why? What would often happen is your brand new telephone instrument would ring. With much anticipation someone would pick it up, hear nothing, and then hang it up. Before the phone became reflexive to use, we had to invent a protocol. It was saying the word "Hello" right after you picked up the receiver. Every one of you out there was trained to do this as a child, because it's just not obvious for a person, when a new device "rings" in their home, to pick it up and say the word "Hello."

Before this protocol came into common use, people would pick up the phone, hear nothing, and then hang up. Often people would have to try two or three times before someone would make a noise on the other end to signal the caller that the circuit was complete. Teaching people to say "hello" fixed this.

I'm not going to talk much more about this, because we're running out of time. But if you look at the real impact of the inventions that changed the course of society, they had one thing in common; they were sufficiently ahead of their time that even the smartest people and the inventors had little clue about what their true value would be. This is why evangelizing about what an immense impact the Internet will have on Education and our lives feels a little like trying to convince the Wright brothers about the merits of the AAdvantage Mileage Program, and why it would become a sensible strategy for their future airline business.

But take any one of society's enabling inventions. You can move forward to radio. Who invented radio? [From the audience: Marconi, Deforest, The Chinese!] Right, the Chinese. And no, not Marconi, but Tesla. His work clearly predated Marconi's, but that's another story. Tesla apparently got government funding for remote control radio transmission of torpedoes (his patent called it model boats). It turns out if you're a scientist working in the technology arena, unless you can steer a torpedo or something, it's pretty hard to get government funding, even then. His pioneering work created the need for info-sec (information security) in the form of jamproof radio transmission. Our Navy guys figured out early on in the evolution of radio controlled torpedoes that there was good news and some bad news. The good news was that they now had a remarkably effective remotely guided antiship weapon. The bad news was that a smart enemy could countermeasure this new doodad and use it against us. If we launched one of these suckers at an enemy ship which happened to have a bigger transmitter on board than we did, they could occasionally take control of it and even steer it back to the sender (once they determined what frequency was being used in the control data link). This was determined not to be desirable by our Naval commanders, at least when it was "them" taking control of "us."

So a very smart woman invented a way to prevent this from happening. She invented a class of spread spectrum called frequency hopping, that putting 88 different receiver channels in the torpedo, and 88 matching transmission frequencies on the boat. In use, a control system would rapidly and synchronously change the remote control frequency by a predetermined random pattern. This made it extremely difficult to jam unless you knew the frequency hopping sequence in advance, and even then it was challenging. Why 88 frequencies? Because she and her collaborator were musicians and they picked 88 because they used player piano rolls as the frequency hopping code storage device. So who was this largely unappreciated technological innovator? (Remember that frequency hopping is still in common military use all over the world.) It was Hedy Lamarr. Why Hedy Lamarr you ask, a famous movie actress? Because her husband built torpedoes for a living, she became aware of the problem, and just solved it. A brilliant and at the time non-obvious concept to which she donated the patent rights to our government. This saved a lot of lives and continues to do so even today. I'd love to meet her some day.

By the way, the use of radio for anything other than point to point communications wasn't obvious either. It took some time to come up with the idea of broadcasting. Namely installing one big honker of a transmitter on a hill somewhere and giving *lots* of people devices that only received. You could use broadcasting to tell stories. And this is how the invention of radio ended up having such an enormous impact.

Things are often the way they are for surprising reasons. Do you know why there's no Nobel Prize in mathematics, by the way? I'm told it's because Nobel's wife ran off with a mathematician, and he therefore decreed there would never be a prize in

mathematics. This came from an occasionally reliable source who swears that it's true. I hope so.

So, anyway, back to the subject of inventions that changed us. Language, writing, printing, telephones, radio and dozens of more we haven't discussed like newspapers, theater, movies, television, and now the Internet have something big in common. (Aside from the fact that their inventors were seldom aware of the true long term value of their contributions to society). They increased the communications bandwidth between human beings. This significantly enhanced the ability of one human being to tell a story to others. Any time in history a technology has been introduced that did this, the invention flourished and it often changed the course of our civilization. Sometimes even for the better!

VR (Virtual Reality) and Interactive Networks (the Internet of today and what it will evolve into with greater bandwidth and better technology) will make inventions like Gutenberg's and Bell's seem trivial. If you believe, as I do, in the idea of better storytelling technology always changing our world, then the Internet could be the most significant invention ever. And just precisely how will the Internet's impact be felt most in the future? I haven't got more than a clue. But I'm perfectly happy to say I'm no smarter than Bell or Gutenberg or Marconi or Tesla or any of those other guys were. They were apparently pretty clueless too, so I can take some minor comfort in my ignorance.

So what? What does any of this have to do with Education in the Information Age? And what does education have to do with the art of storytelling? What does storytelling have to do with war? And what's the role of computers? Boy, oh Boy!

I think it's important, and I'm quoting my friend Alan Kay on this. He teaches a course at UCLA called The Computer Revolution Hasn't Happened Yet. (I would remind you that Alan invented, among other things, the concept of personal computing.) I couldn't say it better. It's important to realize that nothing you have seen to date in the computers will be considered meaningful or important or significant other than as historical curiosities. 100 years in the future what we have now will seem as technologically sophisticated and relevant to our daily lives as parchment and duck quills are today. We've just seen the tip of the iceberg; the real revolution is years off.

Our computers will know that we exist. They will listen to us, talk to us and possess some basic forms of reasoning and common sense. They will not use programming languages as we now know them and will, in fact, program *themselves* the more they are used. We will all be optionally connected and our computers will *learn* to adapt to us rather than the other way around. They will be our pals. Most language barriers will disappear. As bandwidth increases, the fidelity of how they accept and present information will begin to approach our ability as people to perceive and express ourselves. That's when things will get interesting. This will start to happen within the lifetimes of many of you in this room. The connectivity part is just starting to happen now. It's called the Internet.

In the next few years, there will be an extraordinary step up in the effective power of computers for education when we figure out how to couple Virtual Reality with wideband networks. It will also help when computers learn to talk and listen as well as a six year old child does. We are getting close to having non-embarrassing speech recognition software. Close but no guitar.

Now when I say VR I don't mean VR with the sort of junky head-mounted displays and embarrassing images that we have now. This is all pretty pathetic and is only useful for a very narrow range of applications. VR, when it really works someday, will have resolution as good as the human eye can see, and sound with 3D capability as good as the ear can hear, and have tactile senses all as good as we can feel. *That's* what VR *will* be within fifty years. It will be a whole heck of a lot better within ten years.

You may say, "Well, it's hard to do that." Yeah; it's hard to do it now. It won't be so hard in 10 or 20 years. Head mounted displays with ten megapixel resolution will be as convenient to use as today's sunglasses. In a hundred years, we'll probably have migrated towards implants as ways of getting wide band audiovisual data into (and possibly even out of) human beings. By the looks on some of your faces, you seem a bit skeptical. Out of curiosity, how many of you would volunteer for an implant if it could let you fly an aircraft better than anyone else, or, say, learn things ten times faster? Not too many people. [About a dozen people in the audience raise their hands.] A few. Okay. Would you please line up over here? There's a little program I'd like to tell you about.

But, the fact is if you tell someone today that we're going to use implants, it sounds both outrageous and kind of horrific. 1984 all over again. But if we look back at history again, it's amazing how quickly society can learn to accept as commonplace what was once thought of as ridiculous, impossible, or even downright repulsive. For example, imagine that it's thirty years ago and you're in your doctor's office right after experiencing a heart attack. The Doc says, "I've got good news and bad news, which do you want first?" You say, "Tell me the bad news." He says, "You have a bad heart problem and you're probably going to die the next time you have a attack." You're thinking "Terrific."

After a moment you say, "What's the good news?" "We have a brand new experimental technology that could save your life." Hopefully, you reply "Yes, Doctor, what is it?" "We're going to saw your chest open, and we're going to put a computer inside you." Now 35 years ago, you're thinking big iron: a mainframe. "We have to power it, and our battery technology is pretty lousy (it still is, by the way), so we're going to put a little nuclear power plant inside you, a basic plutonium-239 fissile decay thermopile generator. We're going to include an electronic stethoscope (EKG) to listen to your heart, and we're also going to throw in a little electric cattle prod. Basically, the way it works is the computer uses the stethoscope to continuously monitor your heart, if it determines that there is a problem (like it stops ticking or starts fibrillating), we'll kick

the cattle prod on for a moment. With any luck it will get your heart going normally again, and you'll be fine 'til next time. You might not even know it happened!" (You're thinking "Yeah, right.")

I guarantee you that fifty years ago most sane people would have considered this to be a pretty outrageous proposition. Even horrifying. Today it's a routine procedure to do a cardiac pacemaker implant, and that's a miniature version of the system we just described.

Let's create an example that brings it closer to home. The fact is, statistically, some percentage of you in this room are going to go blind during your professional life. You may be hit by a laser (ours or theirs), you may be poked in the eye, you may get a virus, you may be in a car accident, etc. If you're a pilot, this is especially not a good thing. If the doctor came to you and said, "I've got good news and bad news. The bad news is you are completely blind. The good news is we have a new experimental technology that could let you see again. It's a small implant that works like a video camera. It's not going to give you great quality--kind of like bad TV." How many of you do you think you'd opt to be the guinea pig to try this new technology? [Most audience hands go up.]

I think I probably would. And if they said, "Well, a nice added bonus is it's a modular system, so we can keep upgrading it every few years and you may see better and better as time goes on. You're thinking "great!"

So a few years go by and you are back to see your doctor for the High Definition TV quality Seeing Aid Implant. And now, all of a sudden, much to your pleasant surprise you can see better in the dark than you could with your own eyes, because the interesting thing about these systems is you no longer have the limited level of human performance, you can go beyond it. And while he's filling out the options form, and saying what's your favorite eye color, and a bunch of other things like that, his final question is: "And by the way, do you want the fax or Net option?"

The fact is once you have the Seeing Aid Implant to restore your sight, giving you wireless e-mail is just a few more transistors. I think this is how it will happen. No one wakes up and asks for an implant, except maybe that guy in the third row. It's a process whereby the gradual and inevitable progress of technology couples with the evolution of a societies sensibility about what is, and isn't, acceptable.

In the remaining few minutes I'd like to talk to you about is the importance of not getting fooled by wrong assumptions, especially like how we think about education in this country. Generally speaking, accepting wrong ideas won't do you any favors. Amidst all the good stuff, we're all leading our lives with a bunch of antiquated, dumb ideas on education, computers, technology and almost everything else that matters. Just because something is generally believed to be correct, doesn't mean it really is, and that you should accept it without question. Most of our great scientific discoveries came from

people who questioned established ideas. A few of these pioneers got hung for it! And by the way, if you're in combat, wrong assumptions can make you dead in a big hurry. But we all have our heads filled with them.

For example, seeing as how I'm in a room filled with aviators, I'd like to ask you a simple question. When do you think the first manmade sonic boom was heard by anyone on our planet? [Silence from the audience] When was the first sonic boom? [From the audience: 1927?, '43?, '47?, '53.}. Nice try, but I think your thinking is being constrained by your profession. A few of those answers might be fine if you believe it takes a jet aircraft or a missile to make a sonic boom. Quite a bit earlier, bullets did it. (You'd expect more bullet-oriented answers from Army folks.)

The fact is, a few thousand years earlier, whips made sonic booms. A bull whip makes a "crack" because its tip is breaking the sound barrier and creating a shock wave. This is a real sonic boom in every sense of the word. While not a scholar in this area, I suspect that the invention of the whip does, in fact, predate the development of the supersonic jet by a significant margin. The lesson here, if there is one, is that you have to make sure that you are asking the right question (or even more important, understand the possible larger implications of a question) before presenting answers. If not, you might become a victim of the "Ready, Shoot, Aim" syndrome. Often an expensive hobby. I wouldn't be a bit surprised to find out that other sonic booms happened even before whips. Perhaps meteorites...

Let's try another one. How long did the great gorge of the Grand Canyon take to form? Don't be shy. Usually, you hear millions of years. [From audience: five thousand years, fifty thousand, millions.]. The fact is it was probably closer to six months. The best guess I've heard is that it happened very rapidly because a big dam broke, and it all flooded out of some giant lake. People say, "Oh, it's millions of years" because of what we were taught in school, and that way they don't have to think critically about the answer often taught incorrectly.

Well, I'll tell you what. Take a big boulder, and get an eye dropper with water in it, and keep dribbling it on the back of it. Tell me how long it takes to move it ten feet. The fact is it won't move at all. You may eventually erode it, but it won't move. You need a huge amount of water moving very quickly to move large boulders the way you see them scattered along the path of the Grand Canyon. And if the standard erosion argument you're taught in school was true, wouldn't the entire surface of the planet look like the Grand Canyon? I've looked, it doesn't. Do you think it just rained a lot over Arizona? The sad fact is most of us lead our lives believing hundreds of incorrect, fundamentally flawed assumptions. And not only teaching them to others, but actively discouraging them to question and think critically about what we're telling them. How many of your teachers encouraged you to question what they were teaching you?

While in the United States Air Force, many of you in this room have been charged with protecting the security of our nation. This is an honorable and often critical

mission and I'm glad to have people with your dedication and talents on board to do it. But, do you want to know what I think the biggest risk to our national security is in the future? I'll tell you what I believe. It's having an ignorant population. The state education in our country and most of the world today is appalling. Every single one of you over the age of thirty ought to be embarrassed by this. Most of our other big problems like drugs, crime, poverty and even war could be helped if we could make a real improvement in the reach, scope and quality of education. Many would argue that it was information and education that brought down the Berlin Wall and led to the end of what we called the Cold War.

I think we are, as a Nation, making false assumptions about what constitutes a proper education. We think Education is a time to be serious and Entertainment and Fun just don't belong as part of this process. Nonsense! The best and most important parts of learning what any of us has been taught only *can*, but *should* be fun. Learning is supposed to be fun, not punishment. If it isn't fun--and the fact is much of what we now call education just isn't fun for most of us--we are doing something wrong.

So won't technology be a big part of the answer to Education in the Information Age? Isn't it now with computers in so many classrooms? You want technology? When I walk into an inner-city classroom, the most sophisticated technology that I've seen is the metal detectors that frisk kids for weapons when they go into the building. That is the state-of-the-art of the technology. If you want to look at the problems that we are facing and what we have to do, it's taking storytelling technology--which is the only way human beings have ever created to make sense out of information so other human beings can understand them--to communicate it to them in a compelling manner, and this new technology is going to be thrilling for doing that.

Incidentally, I may sound negative about this technology. This isn't the case. I'm both extremely optimistic and extremely impatient. I'm negative about the junk we have to work with today; but the fact is, it's all we've got. We need to work with it to make it much, much better. We *will* get there and then, only then, will the computer revolution really take off. Then it's going to change our lives so quickly that it will make people's heads spin.

In the world of Entertainment, we have channels of communications open to our kids that can be used not just to entertain, but to teach as well. You might even have fun in the process of learning! Perhaps we can even take the skills of our professional storytellers that are now limited to the movie, television and video game business and adapt them to make the Stories told by our teachers more compelling and engaging. It's all about word, pictures and visions after all. I maintain that this approach can work to teach kids, adults, or even our pilots more effectively. Instead of fighting and condemning how people choose to "waste their time" these days watching TV and playing video games, let's put the forces that are fueling this seduction to work in the service of increasing knowledge. Within a very few years the quality of the best

entertainment video games will exceed our current military training simulations. How many of you have noticed that they're just about equal now?

You folks out there are among the jewels of our nation. You are some of the extraordinary assets that we have to not just maintain, but improve, our way of life and help fix some of these problems. But if you think the threat is Bosnia, or if you think the threat is the former Soviet Union, you're wrong. It's ignorance. I don't care if you're talking about crime, or drugs, or terrorists. Not all, but the vast majority of these problems start with a poor education, no family structure, and a lack of pride and self esteem. We have, for the first time, with these new storytelling technologies, the beginning tools with which to give educators the equivalent of Power Steering. With modifications, incidentally, this same technology can give our warfighters power steering; it gives them the ability for one trained person to do the job of many. This would seem to be the secret of how to maintain our military might in the face of drastically reduced budgets.

We're not talking about replacing people; it's quite the opposite. We're talking about using technology to empower them to be better prepared, more effective and more efficient. *We can't get by with just technological overmatch, we need educational overmatch, as well.* Put an American pilot and some other nation's pilot in the same make and model aircraft and send them into combat. I'll put my money on our guy every time. This isn't because of any innate superiority or baseline technology. It's because of education and training. This emphasis on maintaining a clear lead in both technology *and* education needs to remain our highest priorities.

As we're looking at this, I believe if you take the skills of our technologists and combine them with the skills of our storytellers, you have the power to make an amazing difference. By using the power of storytelling to touch their hearts, you can use technology to help open their minds. With this remarkable combination, you can change the world. Maybe even for the better!

I've seen thrilling things here today. I saw a great presentation by some of the cadets here on hypersonic flight technology. They even had the spiffy acronym thing down pat! It could get funded! Great stuff, but we really do have to take this education and the Net thing seriously. As an educator you may not understand why the Internet will become important beyond a research tool, but trust me, it's going to change everything. But it may not change things *for the better*, unless you're an active part of creating it. Don't wait for the technologists to get it wrong and then have to fix it. This is a waste of time and money, and both are precious. Be guilty of being proactive rather than reactive. You can write history and make this technology work as your partner for change. Positive change. But do it *now*!

So, I would advise you, amidst the confusion, hype and primitive technology, to throw yourself in head first, reject false assumptions about what constitutes serious education, cause some of the good kind of trouble, and do *your* part in inventing the

Plenary Speakers' Biographies

Sheila E. Widnall is Secretary of the Air Force. She is responsible for and has the authority to conduct all Department of the Air Force matters including recruiting, organizing, training, administration, logistical support, maintenance and welfare of personnel. Her responsibilities also include research and development, and other activities prescribed by the President or the Secretary of Defense.

In previous positions with the Air Force, Dr. Widnall served on the USAF Academy Board of Visitors, and on advisory committees to Military Airlift Command and Wright-Patterson Air Force Base, Ohio. Dr. Widnall, a faculty member of the Massachusetts Institute of Technology for 28 years, became an associate provost at that university in January 1992. A professor of aeronautics and astronautics, she is internationally known for her work in fluid dynamics, specifically in the areas of aircraft turbulence and the spiraling airflows, called vortices, created by helicopters. She has served on many boards, panels and committees in government, academia and industry. The Tacoma, Washington, native is the author of some 70 publications. She assumed her current position August 6, 1993.

Peter B. Vaill is Professor of Human Systems and Director of the Ph.D. Program at George Washington University's School of Business and Public Management. He is the former Dean of that School. He has also served on the management faculties of the University of Connecticut and the University of California at Los Angeles, and was Visiting Professor of Organizational Behavior at the Stanford Business School. He holds a Bachelor's degree from the University of Minnesota and MBA and DBA degrees from the Harvard Business School.

His special fields of interest include Strategic Management, Organization Development, Cross-Cultural Management, Managerial Learning, and Leadership, with special attention to the spiritual problems of modern organizational leaders. His essay, "Toward a Behavioral Theory of High Performing Systems," (1972) was the first contemporary theory of what has come to be called "organizational excellence." In 1985 he was described in the *Training and Development Journal* as one of the top ten Organization Development specialists in the country.

He has worked with many well-known corporations and with most of the major agencies of the United States Government, as well as with many universities, health systems organizations, and professional associations. His work has taken him to Belgium, Egypt, Germany, Great Britain, Holland, Iran, Japan, Scandinavia, and Switzerland.

Lieutenant General Ervin J. Rokke is President, National Defense University, Washington DC, whose mission is to ensure excellence in professional military education and research in the essential elements of national security. He is responsible directly to the Chairman, Joint Chiefs of Staff, and exercises jurisdiction over all organizations, establishments, facilities and personnel assigned to the National Defense University.

Lt Gen Rokke was commissioned as a Second Lieutenant through the US Air Force Academy, in 1962. After receiving a graduate degree in International Relations from Harvard University, he completed intelligence training at Lowry Air Force Base, Colorado. Intelligence assignments in Japan and Hawaii were followed by a tour as an instructor at the Academy. He returned to Harvard University and received a doctorate in international relations in 1970. General Rokke was the US Air Attaché to the United Kingdom before being selected as the Dean of Faculty at the Academy in 1983. He witnessed the last days of the Soviet Union as the US Air and Defense Attaché to Moscow between 1987 and 1989, and later served as Director of Intelligence, US European Command. Prior to assuming his current position, he served as Assistant Chief of Staff, Intelligence, Headquarters US Air Force, Washington DC.

General James P. McCarthy is the Olin Professor of National Security at the US Air Force Academy. He retired from the Air Force in December 1992 after completing 35 years of service. His last command was deputy commander in chief, European Command, Stuttgart, West Germany, where he was responsible for all US Forces in Europe.

General McCarthy was born in Canton, Ohio. He earned a Bachelor of Science degree from Kent State University and a Master of Science degree in International Affairs from George Washington University. He completed Squadron Officer School, Industrial College of the Armed Forces and the National War College.

Early in his career, General McCarthy was an Air Officer Commanding at the US Air Force Academy and returned to become the Vice Commandant of Cadets. As the Olin Professor of National Security, he is actively engaged in teaching and original research. A number of his writings and lectures have been published in a variety of journals in both English and Spanish.

Lieutenant General Ervin J. Rokke is President, National Defense University, Washington DC, whose mission is to ensure excellence in professional military education and research in the essential elements of national security. He is responsible directly to the Chairman, Joint Chiefs of Staff, and exercises jurisdiction over all organizations, establishments, facilities and personnel assigned to the National Defense University.

Lt Gen Rokke was commissioned as a Second Lieutenant through the US Air Force Academy, in 1962. After receiving a graduate degree in International Relations from Harvard University, he completed intelligence training at Lowry Air Force Base, Colorado. Intelligence assignments in Japan and Hawaii were followed by a tour as an instructor at the Academy. He returned to Harvard University and received a doctorate in international relations in 1970. General Rokke was the US Air Attaché to the United Kingdom before being selected as the Dean of Faculty at the Academy in 1983. He witnessed the last days of the Soviet Union as the US Air and Defense Attaché to Moscow between 1987 and 1989, and later served as Director of Intelligence, US European Command. Prior to assuming his current position, he served as Assistant Chief of Staff, Intelligence, Headquarters US Air Force, Washington DC.

General James P. McCarthy is the Olin Professor of National Security at the US Air Force Academy. He retired from the Air Force in December 1992 after completing 35 years of service. His last command was deputy commander in chief, European Command, Stuttgart, West Germany, where he was responsible for all US Forces in Europe.

General McCarthy was born in Canton, Ohio. He earned a Bachelor of Science degree from Kent State University and a Master of Science degree in International Affairs from George Washington University. He completed Squadron Officer School, Industrial College of the Armed Forces and the National War College.

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Len Barron is a playwright, performer and educator. He holds degrees from the University of Colorado and the Antioch-Putney Graduate School, and has taught at the University of Colorado, San Diego State University, Prescott College in Arizona and Dull Knife Memorial College on the Northern Cheyenne Reservation in Montana. He has been an interview host and producer on public radio in Boulder, Colorado. He has written and directed five theater pieces including *Walking Lightly...A Portrait of Einstein*, with which he has been touring the country since September of 1989. Over these years he has given workshops with students and faculty at all levels. These workshops borrow from the elemental quality of Einstein's manner and thought: being fair, doing things beautifully, and playfulness.

Edward A. Feigenbaum is Chief Scientist of the US Air Force, Washington DC. He serves as chief scientific advisor to the Secretary of the Air Force and the Chief of Staff of the Air Force and provides assessments on a wide range of scientific and technical issues affecting the Air Force mission.

Dr. Feigenbaum has served on the Advanced Research Projects Agency (ARPA) Information Science and Technology Study Committee and on the National Research Council's Computer Science and Telecommunications Board. He has been a faculty member at Stanford University for 29 years and is founder and co-director of the Knowledge Systems Laboratory, a leading laboratory for work in knowledge engineering and expert systems. A professor of Computer Science, Dr. Feigenbaum is internationally known for his work in artificial intelligence and expert systems and is the co-author of seven books and monographs as well as some 60 scientific papers. He is a co-founder of three start-up firms in applied artificial intelligence and has served on the board of directors of several companies. He has served as a member of the Board of Regents of the National Library of Medicine of the National Institutes of Health; and as a member of National Science Foundation's Computer Science Advisory Board.

Linda Bunnell Shade is Chancellor at the University of Colorado at Colorado Springs (UCCS). She began her academic career in 1970 at the University of California Riverside where she was an assistant professor of English and the acting associate dean in the College of Humanities. From 1977-87, she was the California State University Dean of Academic Affairs for Academic Programs and Policy Studies and the Associate Dean and Assistant Dean of Academic Program Improvement. When named the chancellor at UCCS, Dr. Bunnell Shade had served the Minnesota State University system as the Vice Chancellor for Academic Affairs for six years.

The Changing Contexts for Higher Education
Discussions organized by Dr. Roger Benjamin & Col Charles Yoos
Report prepared by Col Charles Yoos

Education in the Information Age Conference
April 17-19, 1996
United States Air Force Academy, Colorado

Approach

We "fast-forwarded" to 2096 to remove any inhibitions about freely envisioning and hypothesizing without constraints.

We understood that in a linear and sequential conference process, foreseeing the changing context for education would be the critical first step. However, we recognized that this conference enacted--*as an example of the topic!*--a simultaneous and interactive conference process, and so our work informed, but at the same time was informed by, the work of other panels.

Major Themes

Globalization - We foresaw the shift from a nation/state, or even global system, to a solar system of, possibly governance, but certainly interactivity. In our judgment, the historical image of mankind's reach is a hand grasping outward.

Connection - If *now* is the information age, we foresaw *then* as being the age of complete connectivity, enabled by technology, of anyone with anyone at any time for any purpose. We conjectured whether the "virtual reality" of an electronically-connected relationship between student and teacher could be a "surreal" environment, an unnatural juxtaposition that might distort, not enhance, the learning process. Yet, the prospect of nearly instantaneous access to knowledge and knowers will surely prove compelling.

Language - We foresaw the emergence of a universal technical language, which we dubbed "unitechnolanguage," to reconcile the Babel we {think we} have now. We did not believe that cultural-linguistic differences will vanish (Anyone here speak Esperanto?) but our projection of the computer base of education in that future leads us to predict an inexorable move toward a more unified communication system as a practical necessity.

Technology - We foresaw virtual reality of such high fidelity, perhaps accessible at web sites, as to make any experience "really" available to anyone. At the same time, as above, we anticipated unanticipated "surrealities" to accompany such experiences. Thus, technology presents the ongoing dilemma of being at once a pact with God and the devil.

Social - We foresaw the possibility of an increasing disparity between the "haves" and "have-nots," based on their unequal access to information; that is, the emergence of an "information elite." We acknowledge that having access to information is NOT per se to have knowledge and understanding, especially via an internet of sometimes unknown veracity. Yet, perhaps even just immediacy of access creates the prospect of "information arbitrage," a "Sting"ing possibility!

Workforce - We foresaw the "Vagabond Worker," who has no long-term organization or career identity, and goes from job to job, sometimes by choice and other times by obsolescence, continually re-educating herself. This worker might serve a number of employers without ever physically relocating. The implications of such an employment concept are various and important: for example, a "portfolio career" might replace a corporate career; a team is at most an *ad hoc* notion; the traditional workplace socialization will not be available. Perhaps there will be a rebirth of family and community as socializing contexts. Given that the conference was hosted by a military service academy, we could not properly avoid thinking about how this might affect a military "career"--will such an arrangement even exist as a foundation of national security?

Values - We worried about how values will be maintained and passed down in society, and speculated that the education system will be asked to do this. We considered the notion of school in general as a "pillar of benevolence," We took interest in the possibility that new technologies (connective and informative) in education, which foster individual cognitive learning (pace and style), might also nurture the development of values. Yet, in another regime of values, factors such as the information "haves" v. "have nots," and an employment situation where obsolescence quickly spells unemployment and loss of livelihood, an education and work revolution could spur an actual societal revolution!

Higher Education - We foresaw a complex and multifaceted system, with dedicated "superuniversities" as honest seekers and brokers of the truth, yet unlimited accessibility, at least by the "haves," from 2 year olds to 102 year olds, to the network of learning. "At the end of the day..." of the conference, our view of the role of education in this changing context can be defined by two core values: that we educate in order to develop individuals who benefit humanity (at the Air Force Academy, the *soldier-scholar-citizen* ideal); and, that education be dedicated to equal access to reliable information and valid knowledge.

The Future of Universities and Service Academies as Organizations

Discussions organized by Dr. Carl Pletsch & Col Joseph Burke

Report prepared by Dr. Carl Pletsch

Education in the Information Age Conference

April 17-19, 1996

United States Air Force Academy, Colorado

Focus Questions

Members of the three discussion groups pursuing "the future of universities and service academies as organizations" started with a short set of focus questions and a longer list of controversial assertions prepared by Col Burke and Dr. Pletsch in consultation with the group facilitators, Lt Col Jeff Johnston, Lt Col Bill Schmidt & Maj Gwen Hall. The following focus questions were proposed in a preliminary meeting of the three groups together.

1. How will broader changes in our society impact institutions of higher education?
2. How will resources in higher education (people, facilities, equipment, support staff) be redistributed in the networked information age?
3. Which organizational features of universities and service academies will be revolutionized and which will remain substantially unchanged?
 - What strengths/weaknesses of our system of higher education will help or hinder change?
 - How are colleges and universities currently responding to changes in our society in general and to the information age in particular?
4. How will the assessment of learning and instructional efficiency change?
5. Will colleges, universities and service academies become obsolete?
6. What impact will the general climate of change in higher education have upon service academies in particular?

These questions provided points of departure for the three groups of approximately ten discussants each. The questions were substantially reinterpreted during the discussions of the next several days.

Results of the Discussions

I. Institutions of Higher Education in general

Broad consensus emerged that colleges, universities and service academies would not be replaced by the internet or simply become irrelevant. Instead, most discussants believed that institutions of higher education would become more differentiated in response to

increased competition. There will be not one but *many futures* for higher education. Each institution of higher education, whether it be of a new type, such as the corporate training center, or one of the surviving institutions of the more traditional sort, such as the liberal arts college or state university, will have to clarify its particular mission, target customer base, and so on. Institutions of higher education are all likely to experience pressures to-

- ... reduce the cost per student of higher education
- ... treat students more as consumers and compete for their tuition dollars
- ... provide evidence of learning and value added
- ... reduce emphasis upon liberal arts and enhance emphasis on practical training
- ... compete with businesses that attempt to educate their own employees
- ... link themselves more closely to business to ensure the employability of their graduates
- ... use active practitioners as part-time instructors in order to provide real world exposure to their students
- ... provide internet connectivity and access to data bases to all students
- ... provide attractive and effective distance learning programs
- ... focus more on "continuing education" and redefine it for a particular constituency
- ... assess teaching and learning more assiduously
- ... provide certificates for specific training programs alongside the traditional degrees
- ... use more adjunct professors to teach more students for less compensation
- ... modify if not abolish the tenure system
- ... appeal to a more diverse student body
- ... provide more services directly to the community
- ... reallocate resources to emphasize teaching
- ... out-source many services currently provided by the college or university

Given the great diversity of type predicted by the discussants, it goes without saying that different universities will resist or welcome these pressures in differing degrees. But these seem to be broad tendencies for the future.

II. Service Academies

There was also consensus that the service academies would survive. Discussants believed the academies would become more rather than less important, as a consequence of greater technological sophistication in the armed forces, the growing importance of information age technology, and larger social changes in society. The academies exemplify the sort of specialized institution that will become more common, providing niche education.

Agreeing that the academies would survive, the discussants also thought that the academies must change to accommodate these changes. Anticipated changes include -

- ... modifications to the core curriculum, i.e., reduction in the number of required core courses, to provide a more differentiated education
- ... expansion of the responsibilities of the faculty to provide life-long learning and training for Academy graduates and perhaps the officer corps generally
- ... increased importance of the Dean's Educational Outcomes (increased accountability), with the addition of greater computing and networking competence
- ... more opportunity allotted for cadets to reflect upon their work, and greater emphasis upon critical thinking
- ... better coordination of the demands on cadet time, to permit them to concentrate on their courses during the semester

Other issues that were discussed without reaching agreement, but nonetheless worthy of note due to strong minority opinion include -

- ... greater emphasis upon instilling the characteristics known to correlate with success for officers in the Air Force
- ... possibly reducing the four-year residence requirement
- ... greater definition of the third class year, where it appears cynicism is currently fostered
- ... reexamination of the fourth class system, which some discussants thought degrading

Members of all three discussion groups recognized that the services academies have a different "customer" than most institutions of higher education, namely the federal government. Legislation and the needs of the armed forces are likely to shape the impact of the information age and other social trends more here than in other contexts.

General Conclusions

Consensus emerged that colleges, universities, and service academies are likely to change a great deal, but the changes will only enhance the importance of higher education in our society.

Many discussants foresaw some dangers as well as many opportunities in this time of rapid change. Decreasing employment security for the faculty and the danger of creating a technologically deprived underclass with no access or ability to use information age technology were two of the most salient concerns.

Society at large will place greater demands upon institutions of higher learning. At the same time, it seems likely that public financing will decline even as more students present themselves to be educated. This will probably result in the continued growth of corporate training institutions and even enhance the role of private universities.

The proportion of resources devoted to the various activities of colleges and universities will undoubtedly change. Funding for research will decline as teaching assumes greater importance in institutional missions. And as public contributions decline, the cost of education (to students) will climb. These projected trends raise some fundamental questions about the contribution higher education will make to our society in the future. Will national competitiveness lag as research declines? Will the greater cost of education lead to even greater disparities in social stratification?

A final thought: as the pace of change increases, it will become progressively more important to anticipate the future. Colleges and universities will likely be held accountable for their ability to anticipate the future. The graduates of institutions that do this best will have an advantage in the job market. Consequently, institutions of higher education will probably devote significant resources to the study of the future.

Learner-Centered Education

Discussions organized by Dr. John Darley & Col David Porter
Report prepared by Col David Porter

Education in the Information Age Conference
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Introduction

It took millions of years for evolution to shape the way humans live and learn. Although the *information age* is marked by profound changes in the quantity, quality and availability of information, much of what goes on between human ears is likely to remain unchanged. Human learning is the key to education; however, because learning can seldom be directly observed, it remains the object of considerable misunderstanding and superstition. A question inherent in any consideration of learning is "by what criteria is learning to be measured?" Dr. Darley suggested ways in which measurement and morality interact to shape teachers' as well as students' learning experiences. In particular, he pointed out how even the best-intentioned use of competition is likely to create classroom conditions which are ultimately inimical to the development of intellectual curiosity and intrinsic motivation. Following the panel presentation, Col Porter facilitated a direct learning experience for conference delegates. Afterward, participants reflected and built consensus in small groups to identify the most critical issues to explore further. Better understanding human learning is an absolute prerequisite to managing the effects of and capitalizing on the opportunities provided by the information age.

John Darley's Opening Remarks:

The assessment of learning is both essential and dangerous. By "assessment of learning," one refers to those processes, generally resembling tests, by which we discover what has been absorbed by an individual following that individual's exposure to education. Assessment, then, is when we learn what has been learned. Assessment is essential in that it allows learners and those managing the learning systems to discover what the learners have learned, what remains to be learned and taught, and in what contexts the learned material can be made to function. Without assessment, educational systems are likely to drift off course and provide little of value or relevance to society.

But assessment is dangerous, in the sense that the systems installed to measure learning outcomes often work to destroy what they purport to measure--student learning. This is so because these systems, striving to be "objective," often test for the retention and regurgitation of facts rather than the acquisition of problem-solving strategies in new domains. Relatedly, tests often seek to deliver a rank ordering of test takers along a single dimension of bad to good, stupid to smart, rather than a knowledge of what has been acquired, and what remains to be acquired in the fields that the teaching has explored. Worse, as the learner's standing in the rank-ordering becomes more

consequential--as more of his or her life outcomes are made to depend on it--the student is pressured to deviate from his or her internal responsibility for control of the learning process, and to conform to the memorization and test-taking rituals imposed by a poorly designed examination process. These same pressures can lead to "cheating," although how one defines the difference between cheating and an appropriately limited investment of time and energy into fulfilling meaningless rituals is difficult to say.

The tension is obvious. Those assessment activities which appear to provide immediate, objective, and precise information, although appealing to administrative authorities, all too often are corrosive of the true learning process. They substitute appearance for substance, and undermine the authenticity of the learning experience.

If the tension is obvious, solutions are difficult. When possible, we need to invest control of the assessment process in the hands of the learners, leaving them to discover what use they can make of what they know, and what further they need to learn. Further, even when assessment of learning has an authority-imposed component, we need to consider the extent it can focus on measuring knowledge and skill acquisition and problem solving abilities, rather than producing value-laden rank-orderings of its victims.

Large Breakout Session

Following the panel presentation, Learner-Centered delegates reconvened in a lectinar. To remind participants of the learner role, they were asked to assume the role of students, asked to perform an apparently meaningless task, and then given a pop-quiz on what they had learned. However, the "meaningless" task, differed for two groups. The instructions on the answer sheet for half the participants asked them to rate the twenty sentences read to them on their relative ease of pronunciation. The other group's written instructions asked them to rate the same sentences on how easy it was to visualize the action taking place. The quiz consisted of 20 questions asking students to identify the subjects of the 20 different activities they had just been read. Participants did not know that there were alternate instructions, however, as a foil they were "arbitrarily" divided into two groups and asked to compete with one another "just to make it more interesting."

Results:

F	4																			O	O - Visualizing Group
r	3																			O O O	X - Verbalizing Group
e	2																			O O O O	Bold - Median member
q	1	X		X	X	X	X	X	O	X	X		X		O	O	O				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		Number of correct responses out of 20 possible.																			

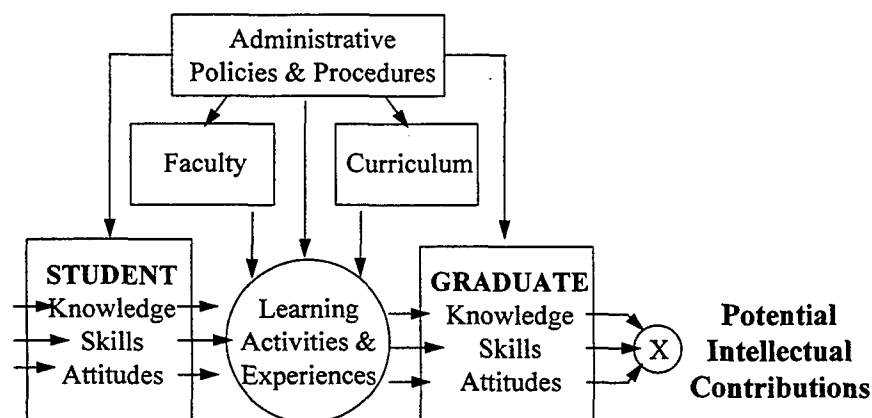
These results clearly show the power of process on what is learned or retained. Although the material to be learned in this demonstration was of dubious relevance, it is important to realize this is exactly the way many of our students view much of what we seek to

teach them. The median scores of the two groups (in bold print) suggest the visualizing group retained over twice as much of the information as did the verbalizing group. This exercise also reacquainted participants with the feelings associated with being a student, doing tasks that seem irrelevant and unimportant, taking pop quizzes and performing well or poorly and being compared to classmates.

Participants were then asked to generate ideas and issues worthy of discussion and inquiry by the smaller breakout groups. Some of these topics included:

- learning styles and their interaction with learning processes and mechanisms
- the real and imagined effects of competition on individuals and groups
- the debilitating effects of fear of failure and test anxiety
- how prior knowledge or experience affects the rate of comprehension and retention (i.e., the value of contextual associations)
- how knowing the objective enables students to focus their attention appropriately
- the importance of striking a balance between boredom, novelty and chaos
- how motivation is affected by diverse factors (both internal and environmental)
- the role of individual aptitudes and abilities and how they are used in class
- how valuable relevance and applicability are to sustaining motivation
- how visualization and context can affect recall and retention
- how powerful the effect of attitude can be on the entire learning process (from attention to acquisition, retention and eventual regurgitation of knowledge)
- what an awesome responsibility teachers have to consider all of the above and create an environment where all students can and do learn

The general educational model shown below was proposed as a theoretical frame for discussing the interaction of several kinds of learning (i.e., changes in knowledge, skills and attitudes) involved in educational system.



Delegates were then asked to self select into three groups of approximately equal size to explore each of the three learning channels suggested by the model (viz., knowledge, skills and attitudes). Each of the three facilitators led one of the sub groups and provided a brief introduction to their topic. After these groups reached closure on each of these theoretical learning channels, delegates were "reshuffled" and distributed into three equal groups. These new groups were asked to work in parallel on the question of prioritizing initiatives to reform educational systems to re-establish the control of learners. Facilitator impressions of both sessions are continued in the following reports:

Knowledge (Capt Sandy Eisenhower)

Processes involved with acquiring knowledge will not change as a result of new technologies introduced into the classroom (or replacing classrooms). Thus, the individuals in this group decided to create a working definition of "knowledge." They then constructed a list of important considerations and constraints regarding the processes involved in the acquisition of knowledge. These considerations should be used to frame the integration of technology into educational settings.

The implicit model of knowledge as a *thing* stored in a *place* was unanimously denounced. In contrast, emphasis on approaching knowledge as a dynamic processing of information for some useful purpose was widely accepted. For our purposes, the working definition of knowledge agreed upon was: *the acquisition of data (including processes) and the data of when/how to use these data in appropriate contexts.*

In order to use technology to facilitate the acquisition of knowledge, we must first understand the processes involved. In the time permitted, the following list of considerations was created:

- We (all people) have dormant and inert knowledge which needs to be used as a resource for further knowledge acquisition.
- New information is acquired by mediation with our existing models and experiences; we must fit new data into what we already know.
- Acquiring knowledge includes students becoming more aware (stepping back and taking a metacognitive perspective) of their own processing, models they are using, etc. Hence, learning is an activity of reorganizing existing knowledge to include new information.
- Individuals have different learning styles; every learning style will benefit from a *variety* of teaching styles.
- Cognitive elaboration is necessary for acquiring information. The more elaboration, the more one learns and can use the knowledge learned. Elaboration occurs at many different levels. Deeper elaboration (versus shallow, e.g., rote rehearsal) creates greater retention and more flexibility.
- Underlying philosophies and attitudes of learning, knowledge, and intelligence (which are usually implicit/unconscious) are important to address; they influence how students engage in cognitive activities and what they consider to be "learning" and "knowledge."
- Interpersonal relationships are important to human learning. Human interaction and feedback foster intrinsic motivation. Implicit learning (e.g., modeling instructor's problem solving approaches, etc.) and implicit pattern formation cannot be underestimated.
- Short term meaningful goals should accelerate learning. Intrinsic motivation is critical--if a

- Short term meaningful goals should accelerate learning. Intrinsic motivation is critical--if a student sees purpose and meaning to learning, intrinsic motivation is likely to occur naturally.
- Long term goals are also important to address. Helping students see how what they are learning fits into the context of a "bigger picture" provides relevance and meaningfulness.
- Individuals are at different maturity levels and therefore, ready for different kinds of learning. In other words, there are different ways in which knowledge is organized which tend to occur in a specific sequence, and "teaching" should be geared at the appropriate levels. (If the level of instruction is too high, no amount of extra effort by students can compensate for the mismatch.)
- Learning/knowledge acquisition is a continuous process that does not happen in a ballistic fashion. Learning in a specific domain may use terms that are unique, but knowledge of patterns and associations comes from learning across different domains.

A common theme of our discussions was the idea that we, as educators, must move away from the "traditional" model of viewing the student as an empty, compartmentalized bucket waiting to be filled with data poured in by different instructors. The ideas listed above are not an exhaustive list, but provide a basis for considering what impact technology might have on important aspects of the educational process.

The final session of discussions was aimed at answering one question: If we took learner-centered education seriously, what would be our priorities for educational reform? The following list of points were highlighted, but were not placed in a prioritized order:

- Educational systems need to make sure technology is used as an aid or supplement, not a driver.
- The student needs to be the focal point in class and out, not the instructor.
- An emphasis must be placed on student-teacher relationships, especially in the "first year experience" of students.
- A whole new philosophy needs to be adopted institution-wide: teachers and administrators must model the role of learner. Risk taking and handling of "failure" in front of students is a valuable source of learning; teachers do not need to be fonts of flawless wisdom with all "the right answers." Teachers are people with expertise in their fields and skills which help them think, solve and resolve problems. Most teaching should not be "directed at" students, but rather, teachers' roles should serve as facilitators or coaches. For this to happen, there must be broad changes to our curriculum and, even more importantly, to the "climate" in our classrooms.
- Consistent with the point above, a cross-disciplinary approach is needed--with budgets and faculty and curricular policies adjusted accordingly.

In terms of the general education model, it is clear that knowledge and the acquisition of knowledge are driven by institutional-level policies and procedures, which are reflected in actual classroom practices. Not surprisingly, many of the considerations regarding what we know about how people acquire knowledge are directly related to the priorities for educational reform.

Skills (Major Tony Aretz):

This group examined student thinking skills, how they are influenced by education, and how the information age may influence their development. The session started with Maj Tony Aretz presenting the Reflective Judgment Model and other general concepts about human thinking. USAFA's educational outcome that officers graduate with the ability to

frame and resolve ill-defined problems served as a starting point for discussion on what we mean by thinking skills:

Ill-defined problems are ambiguous, interactive, and ever-changing. *Framing* means constructing a working model, and revising it based on feedback. *Resolving* means that an ill-defined problem is never solved for good; rather it is solved again and again (re-solved) as the problem is framed again and again; and, each successive solution is more refined (resolution).

Next, the Reflective Judgment Model was presented. This model, supported by empirical research, suggests thinking skills develop throughout life and education has a positive influence on this development. According to the Reflective Judgment Model, thinking is distinguished by distinct sets of epistemological assumptions about the nature of knowledge (i.e., whether knowledge is always certain or can be uncertain) and how beliefs are justified (i.e., by biases or a reasoned argument). The data show that reflective judgment develops throughout life and is enhanced by higher education. The highest level of thinking acknowledges that some problems are ill-defined, but can be solved through reasoned argument. This highest stage is compatible with the educational outcome described above. However, data indicate this level of thinking may be difficult to achieve among undergraduates.

After this presentation, discussion continued on how best to design an educational system to promote higher levels of thinking. Delegates concluded that most educational systems are far from optimal. Most current educational practices emphasize knowledge retention (e.g., "academic bulimia," as USAFA's Dean is fond of saying) at the expense of deeper mental processing. There seems to be a strong assumption that a course must cover the entire textbook (i.e., an emphasis on content) for quality learning to occur. The desired alternative is for courses to embrace a problem-centered curriculum that retains coverage of essential knowledge, but requires students to actively engage their minds in using the knowledge (i.e., more an emphasis on process). Research in cognitive psychology suggests this kind of learning aids long term retention of the material. Rote memorization is the least effective form of learning. Another advantage to problem-based learning is that it teaches students how to learn. Learning how to learn was mentioned by several of this conference's featured speakers as an essential goal of higher education as we approach the information age.

Unfortunately, many of the participants saw most of our current educational systems as being rigid, inflexible and likely to be extremely resistant to the needed innovations. In addition to its emphasis on knowledge, competition for grades among students (and resources among departments) was seen as a major hurdle to overcome in making progress toward problem-based learning. One suggestion was the increased use of student portfolios that might be evaluated by a panel of teachers. Another suggestion was to design an evaluation system that encourages steady growth and success built upon learning from mistakes and misconceptions, rather than giving students a single shot at

success or failure. Possibilities in this direction include paper drafts and rewrites, an opportunity to retake exams, and both in and out of class collaborative learning opportunities.

Another point made was that information technology may facilitate transition to developing and elaborating problem-based pedagogues. The tremendous increase in the availability of information through innovations such as the World Wide Web may free the teacher to be more of a coach and mentor to students, rather than a vessel of knowledge that must be passed on. Unfortunately, many participants thought that *technology* was the current driver behind change rather than *student learning*. As Secretary Widnall suggested during her keynote: "Visually dazzling garbage is still garbage."

Another hindrance to educational innovation mentioned was the disciplinary specific structure of our university administration and course offerings. An interdisciplinary approach is what is really needed to teach students how to think at the "Edge of Chaos" or "Permanent White-water"—thinking skills two of our keynote speakers suggested were necessary in a future that is inherently dynamic and unpredictable. However, discipline specific systems that encourage politics and competition were seen as the major roadblock to educational innovation. *A priori* claims to the exclusive use of particular labels or concepts are perceived by many as barriers to the development of broader interdisciplinary perspectives.

Using a metaphor that one of our keynote speakers suggested previously, we have to learn how to fertilize the soil of the mind before we can expect it to produce a lush garden. What we do now is force good seeds into barren soil. Before we plant the seeds, we need to make sure the soil is ready. Current educational processes seem to assume the seeds will fertilize themselves, but this frequently does not happen. Teachers need to not only plant the seeds, but ensure the seeds receive the nurture and support they need to fully develop.

Attitudes (Dr. Jeanne Smith)

Our group decided to define *attitudes* in terms of the current USAFA educational outcomes. After a brief discussion of what constituted a positive attitude toward learning, we refined our definition of attitude as *intellectual curiosity* and *motivation to learn*. Our group then outlined its main challenge as trying to generate a list of recommendations to encourage intellectual curiosity in the classroom of the 21st century. While we agreed that intellectual curiosity was something that developed inside each student, we also felt that much could be done by the teacher and the organization/culture to encourage its development. In the course of our discussion, we developed a series of recommendations in each of these areas:

Students: We felt that students should focus on *self*-assessment. Rather than depending on a teacher or an exam to evaluate their performance, students should develop an

awareness of their own level of expertise and take responsibility for it. Obviously, teachers can help with this process. One way in which self-assessment can be increased is by allowing students to give feedback to *each other*. We felt that this would give students greater ownership of the material. Ideally, we would challenge students to switch roles with the teacher -- to take a role in designing their courses, evaluating their progress, and deciding the direction their learning will take.

The teacher: We agreed that the teacher's role in this new system would be as a mentor and guide rather than simply an evaluator. Teachers should provide a variety of assessment opportunities for students instead of focusing on standard evaluations. Teachers need to give students more autonomy and a larger role in decision-making. Most importantly, however, teachers need to show a personal concern for *each* student -- not just the top or bottom students. They must engage all students, encourage them to ask broader questions, encourage feedback, and make the material personally relevant to students. Of course, in order to do this, it will be critical for teachers to know *themselves*.

The culture: None of these changes can occur unless the culture will support them. In order to develop intellectually curious students and caring, supportive instructors, the system must reward students and teachers for taking risks, making mistakes and learning from the experience. In this endeavor, *all* components of the system need to have the same basic goals. If one part of the system rewards rote memorization and "gaming the system," the efforts of others to encourage a broader view will be for naught. In this system, all students should be important as well. We cannot afford to devote all our time and resources to only the outstanding students or to those who are struggling. We believe that these changes will allow the vast majority of students, who have immense potential but are disillusioned with the present system, to achieve greater mastery of the material and, in the process, develop more positive attitudes.

All delegates reconvened in a single conference room and briefed their results to Dr. Darley, Col Porter and the rest of the facilitators and delegates.

Dave Porter's Concluding Remarks:

This conference has created a crucible for conversation; perhaps that has been our greatest accomplishment. We've worked together to make progress toward a fuller and richer understanding of education and how it will be affected in the emerging Information Age. Our particular panel addressed the issue of learner-centered education and looked at the processes which underlie human learning. If we assume that technology will have a *multiplier effect* on the educational processes to which it is introduced, it is clear why it is important to ensure that current systems are having positive and facilitating effects on student development. Most of our delegates reached the conclusion that there is insufficient evidence to support the sanguine assumption that technology will have pervasive facilitating effects. Traditional educational systems do not seem to be working either very well or very consistently and using technology to amplify their present influence could be disastrous. Let's look at a few specific examples.

Despite our public rhetoric, the term *learner* is not held in particularly high regard in most contemporary educational systems. *Learners* are slow and awkward, their knowledge is inadequate and despite their apparent eagerness to improve, their performance is likely to fall far short of perfection. Most of us assume that learner-centered education is synonymous with student-centered education and support this perspective out of a sense of charity (and intellectual superiority). In contrast to student learners, many faculty and administrators consider themselves to be *the learned* and go to great pains to remind others of the distinction. Such an attitude renders them incapable of even noticing their mistakes, let alone learning from them and the systems they impose on subordinates continue to do great harm to those they are supposed to help. Perhaps the most significant change we could make would be to openly admit that we as individuals, regardless of our rank or position in the educational food chain, are all learners. Once we admit this we might then be able to get to work on figuring out how to create a culture and climate which encourages and supports improvements rather than makes a pretense of perfection. It is apparent to all of us when a student tries to bluff her or his way through a classroom recitation, why do we assume it is not obvious to others when we do the same?

Topping the list of things we don't know about education is what we don't know about students: what they know, what they think, what they think they know, and how they feel. For us to educate others we must learn more about how the world looks through our students' eyes; creating a crucible for conversation, positive interaction and growth would seem to provide a generic ideal for education within most disciplines and throughout most institutions. We need to work together to create a climate of trust, understanding, and mutual encouragement and support. More than anything else our classes need to become learning organizations (or even organisms).

There are many things we don't understand about education and human developmental processes. Knowledge is not a thing; memory is not a place; and she or he who memorizes the most *stuff* is not likely to be the best educated. "It is not so much the things we don't know that get us in trouble; it's the things we know that just aren't so." The intellectual development of our students is another area of general educator ignorance. Intellectual development seems to naturally develop in distinct stages. Extra effort is not a panacea for improved performance nor can the transition to higher and higher intellectual or conceptual stages be forced by external threats or promises. The pervasive use of competition, evaluation and punishment (viz., the use of fear, ridicule and sarcasm) in the classroom are testimonials to our general ignorance of human development and how to facilitate it. Perhaps the greatest area of faculty ignorance is in the affective realm. As General Cubero, the USAFA Dean, has suggested on many occasions, education is much more an emotional event than a logical or intellectual one.

Although our delegates were forced to look at educational systems and human learning from three distinctive perspectives (i.e., knowledge, skills and attitudes), all groups converged on an appreciation of how deeply intertwined and distinctively essential these three channels of learning are. We as educators have a great deal to learn. We who

consider ourselves teachers, administrators or even leaders need to recognize that we too are learners. We need to talk less and listen and do more. Much of our rhetoric has become a mere patina on our shared misconception of human learning and the educational systems in which we operate. The only thing worse than our ignorance is our shared implicit assumption that our considerable experience and common intuitions will be sufficient to assure a smooth transition into the Information Age. If we are to capitalize on the riches technology has to offer education, we must first recognize and then work to overcome both our ignorance and arrogance. More than anything else, this would help us to become what we are capable of becoming: a truly learner-centered educational institution.

Teaching Methods in an Era of Advancing Technologies

Discussions organized by Dr. Jim Laffey & Col Rolf Enger

Report prepared by Col Rolf Enger

Education in the Information Age Conference

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Overview

With the advent of e-mail, networked classrooms, satellite communications, interactive television, and the Internet, technology is having a sweeping impact on all areas of academia. Faculty looking toward the 21st century must contemplate appropriate educational responses in an uncertain and unsettling future where traditional "assembly line" models of teaching and learning may no longer have relevance. Among others, this working group discussed and debated these key questions: What are the promises of technology? What will education be like? What will teachers do in the future, including those things they are doing now? What will they need (resources, training, etc.) to do these things well? And, what issues and concerns affect teachers now or will affect teachers in the future?

What are the promises of technology?

Technology will change the way faculty work, affecting both teaching and research. There will be more opportunities to keep up with discipline-based and pedagogical innovations through greater information access and sharing. Some predict that technological advances will lower educational costs; others predict that they will rise.

As more technological tools become available, teachers can potentially structure learning to become more effective and efficient. Computer simulations and games, self-paced computer assisted instruction, electronic grading, software computations, and satellite and fiber optic networking can enhance learning and make it more fun. Teachers who no longer need to lecture can use "seat-time," if available, to help students process information and receive feedback on their learning through active learning activities and face-to-face interactions. Overall, integrated technology will make it easier to deliver, assess, and manage student learning, including providing multiple sources of feedback. It will enable faculty to vary their teaching approaches to appeal to virtually all student learning styles.

Technological advances can also increase research productivity through computational programs, through ready access to information on the Internet, and through e-mail and other rapid contact with other scholars around the world. All communication, including interdisciplinary sharing, becomes easier via the World Wide Web, listservs, and electronic conferencing.

What will education be like?

The virtual classroom with its resultant freedom from the tyranny of "seat-time" in the 50-minute class may not become a reality for all students and teachers. However, most faculty will likely opt to use news groups, the World Wide Web and other innovations to replace or supplement their current delivery methods. For example, teachers may draw upon the 21st Century's high-bandwidth computer superhighway to electronically deliver course materials, with appropriate incentives and hypertext links that encourage students to learn on their own. They may also come to rely on that same technology to provide feedback and assessment. Laptop computers will probably prove more versatile and economical than inflexible, rapidly obsolete electronic classrooms.

Education in general will become more learner centered as students and faculty grow more proficient in the use of new technology tools. Ironically, students who become more responsible for their own learning—particularly learning that takes place outside of traditional classroom walls—will also need to become more collaborative. Faculty will need to ensure that news groups and networked software truly enhance learning. They must learn to structure sequenced assignments so that students receive peer feedback and also help one another over pedagogical and technological hurdles. Technologically oriented "golden geeks" may become peer coaches as valuable as the class "grinds." With greater reliance on student-centered, technology-enhanced collaborative learning, learning time itself may lessen.

Teachers, like students, will hone their skills by collaborating with content experts, fellow educators, and others proficient in technology and effective pedagogical approaches. Teachers, like students, must become life-long "super" learners.

What will teachers do in the future, including those things they are doing now?

Students and teachers will never disappear. Furthermore, as the working group on learner-centered education has emphasized, processes involved with acquiring knowledge will not change as a result of new technologies. Thus, faculty must be certain to retain those teaching methods known to be effective. With sound educational goals driving the process, these effective practices must be integrated with technological innovations. Because of their expertise, teachers usually will continue to determine objectives and measure outcomes. They should also continue to use active-learning techniques, particularly well-structured group work in classrooms, laboratories, and on computer networks; frequent, focused feedback; creative use of technological tools; and real-world problem-solving. They should encourage peer coaching among students and similarly enhance their own professional development through team approaches to teaching and learning; faculty sharing and mentoring; and faculty development opportunities. Finally, teachers must continue to be the guardians of accountability for the educational process by establishing meaningful "credentialing" standards and by ensuring that students satisfy requirements before degrees are granted.

Although teachers will never disappear, their roles in the Information Age will differ as the use of technology in everyday life becomes routine and reliable. They will step down from their podiums on stage and become not lecturers, but coaches and facilitators who both guide and motivate students in their learning. They will not only help students learn technology, but they will also help them develop the critical thinking skills needed to sort, synthesize, and evaluate resource materials, including differentiating valid from bogus or superficial information made even more accessible and abundant by technology. Because of their wealth of personal experience and networking, they will help students gain access to wider worlds, structuring lesson plans, practice sessions, and homework to maximize learning within and without the classroom walls.

Additionally, teachers must coach students in their new roles as independent learners and as peer coaches. Students unused to these responsibilities will need to see the value of these approaches before they can hone their skills. Both students and faculty, for example, must become proficient team players who function well in groups. Faculty can coach students to avoid some of the pitfalls of using technology by cushioning them against losses from hardware crashes; providing templates or peer coaches to assist them over technological or educational impasses; and cautioning them about the seductions of mindless web crawling.

Teachers who can accomplish all these things must accept, expect, and welcome change.

What will teachers need to do these things well?

These new roles, including the assessment of technology-based learning, will demand new knowledge, skills, and attitudes. Teachers cannot adopt student-centered learning approaches without an elaborate support network composed of creative administrators, enlightened "techies," responsive faculty peers, and cooperative students. Besides an openness to change, teachers who are to prevail in the Information Age will need the means, the time, and the motivation to keep up with technology and with their disciplines. Because of the inherent complexity of the new era, teachers lagging behind today will be even further behind in a student-centered technology-rich environment. Thus, training is essential; it must cover technology, discipline-based content, pedagogical approaches, and team-building skills. Teachers will require integrated resources and support, including faculty development for those perceived as ineffective. There must be incentives to excel in this new environment. Investments deserve recognition, including those, such as promotion, lying within the faculty reward structure.

What issues and concerns affect teachers now or will affect them in the future?

If there is one thing we all agree upon, it is that we face huge challenges in this "Era of Advancing Technologies." Many of these issues and concerns have been woven throughout this narrative. Others would include the money needed for hardware upgrading, software development and evaluation, training, and other support. Another economic concern is the gap between the "haves" and the "have nots," individuals and

institutions who can afford technology and those who can't. It is costly to build and support infrastructures. Enlightened leaders must be motivated to locate resources and/or convince reluctant politicians to provide funding.

Motivation is needed at all levels. Students must be persuaded to become independent learners, working at times in isolation without the enthusiasm generated by live student/teacher interactions. Faculty too must be motivated to embrace creative, effective uses of technology while avoiding overloading or burn-out.

"Time" is an enormous concern. It is clear that time "windfalls" must be found to compensate for the additional time needed for preparing student-centered learning activities, for electronic interactions, and for keeping up with the latest technological developments. Further aggravating this time problem is the movement away from traditional secretarial support as faculty learn to "do it all." Faculty must see the pay-offs and the offsets for their Herculean efforts, particularly senior faculty who may be resistant to change.

Probably the greatest concerns are about the quality of education in the Information Age. Unmotivated, untrained, undersupported or overworked faculty using technology without substance or purpose will not motivate students or further their learning goals. Teachers concerned with the entertainment aspects of technology—"bells and whistles" during a lecture to capture the attention of these MTV generations—will offer fluff rather than rigor. Quality could be compromised by poor assessment practices, by unchecked electronic plagiarism, and by shoddy certification, continuing education, and credentialing.

Conclusion

Overall, however, this working group remained optimistic. The promises of technology will materialize when thoughtful educators ask the hard questions suggested above and seek solutions that will result in teaching methods embracing the strengths of technological advances while avoiding the pitfalls.

A Hypersonic Attack Platform: The S³ Concept

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The clairvoyant who in 1996 gazes into a crystal ball with the intent of predicting the world of 2025 faces some daunting challenges. Independent of the model that one postulates to describe the world of 2025, the air and space forces of the United States must be able to:

- (1) deliver decisive blows at the outset of hostilities, with the goal of destroying the adversary's desire to fight a protracted war,
- (2) deliver cost-effective weapons to defeat time-critical targets and establish in-theater dominance, if a protracted war cannot be avoided, and
- (3) maintain flexible, readily accomplished access to space.

This paper proposes an integrated, multistage weapons system, which is capable of performing a variety of missions, both strategic and tactical. The design of this weapons system would be based on technologies developed in a variety of previously existing programs.

The S³ is an integrated hypersonic weapon system composed of a supersonic flying wing and a hypersonic Mach 12 airplane which serve as the launch bed for a Mach 8 hypersonic cruise missile (HCM) and a trans-atmospheric vehicle (TAV). The S³ can perform the roles necessary to the Air and Space Forces of the United States in the twenty-first century.

This paper proposes that no matter what model one postulates to describe the world of 2025, there are at least three mission goals that will be essential to the air and space forces of the United States: global reach/global power, in - theater dominance, and access to space. These time critical missions require vehicles capable of hypersonic speeds. This paper presents an integrated, multistage weapons system capable of a variety of missions. This design is based on technologies developed during a variety of previous and existing programs and considered mission planning activities, base operational support requirements, etc.

This weapon system allows the future Air and Space Forces of the United States to achieve global reach/global power, in theater dominance, and access to space.

System Design Constraints

1. The entire study was mission, rather than technology, driven. The technology base for the proposed weapons system should be available now or early in the next century, assuming reasonable developments. Systems requiring breakthroughs in technology were not pursued.
2. Based on a presentation by Blankson, global range within four hours requires flight speeds of approximately Mach 12. To allow time for takeoff and acceleration, we propose a total mission time of two to four hours. Cryogenic fuels are required if the vehicle is to cruise at Mach 12. Thus, the global reach/global power component will use hydrogen as its fuel.
3. The use of cryogenic fuels leads to basing constraints. The infrastructure for mating the multistage weapons system and for fueling and arming the vehicle for its mission will be extensive. Considering the uncertain nature of alliances and security at foreign bases, we

decided to restrict the principal bases for the weapons system to the Continental United States (CONUS). The delivery platform will be able to reach a target anywhere in the world and return to its home base (or a safe haven) without refueling, eliminating the need for a constellation of tankers whose deployment would announce the impending mission. For global reach, there should be four CONUS bases, e. g., Florida, New England, California, and the Pacific Northwest.

4. Although the delivery platform would use cryogenic fuels, the hypersonic cruise missile (HCM) should use endothermic hydrocarbon fuels. This constraint is placed on the HCM, because, in addition to its use on the S^3 , it could be used as an in-theater weapon. In this role, the missiles would be launched from conventional aircraft, such as the F-15E, or from naval surface ships, using the VLS equipment. The use of endothermic hydrocarbon fuels simplifies logistics and the safety procedures. Currently, these fuels limit the maximum Mach number of the missile to approximately 8.

5. To perform the mission goals, the global reach/global power delivery platform should be able to handle two vastly different payloads, (1) the Orbiter for access-to-space and (2) HCM for in-theater dominance. Accommodating the weight and size of the Orbiter will drive capability. Considering this need, the system was designed with a 50,000 pound payload capability.

Characterization of the Proposed Weapons System

The delivery system is a two-stage configuration. The weapons delivery system includes an unpiloted flying wing, which is used to accelerate the weapons system from the runway to supersonic flight at Mach 3.5 at approximately 60,000 feet and a piloted, aerodynamically-efficient, attack aircraft capable of sustained hypersonic flight, known as the Supersonic/Hypersonic Attack Aircraft (SHAAFT). The SHAAFT cruises at Mach 12, at approximately 100,000 feet. The SHAAFT could launch either: a barrage of HCMs or an Orbiter, capable of delivering satellites to orbit, repairing orbiting satellites, or attacking the enemy's space assets. The cruise missile will be referred to as Standoff Hypersonic Missile with Attack Capability (SHMAC) and the Orbiter will be called the Space Control with a Reusable Military Aircraft (SCREMAR). Since the SHMACs have a range of over 1000 nautical miles, the attack aircraft can stand off from the targets, minimizing the risk of losing the delivery system and its crew.

For this integrated hypersonic weapons system, both the flying wing and the SHMACs should be designed as unpiloted aerospace vehicles (UAVs). The SHAAFT acts as a mobile control room wherein the personnel who deploy the myriad of UAVs in their arsenal are transported closer to the action. Using continually updated intelligence, the crew can make better use of the unpiloted assets by modifying the mission profile in real time.

Beam weapons, including high intensity microwave devices, or airborne or space based lasers, can affect the ability of the S^3 system to execute its mission. In addition, if the SHAAFT relies on external navigation inputs such as GPS to accomplish its mission, an adversary with advanced space capabilities could attack those assets as well. Thus, the elements of the S^3 system should have an onboard navigation capability. Laser weapons are currently under

development to provide point defense against theater missiles, such as the SCUD. Conceivably, powerful adversaries could develop beam weapons to intercept (at least some of) the incoming SHMACs.

The flying wing serves as a zero-stage, launch platform. The use of a flying wing incorporating many of the technologies developed for the high speed civil transport (HSCT) (Boeing) to accomplish the initial acceleration of the weapons system provides many advantages, especially in simplifying the design of the second stage vehicle, the SHAAFT. The zero stage will accelerate down a long runway, take off without complex lifting devices, accelerate to Mach 3.5 at an altitude of 60,000 feet, where it cruises to a point within the 5,000 mile range of the flying wing. At this point the SHAAFT stages and continues its mission, while the flying wing returns to its home base or an alternate safe haven, e.g., Hawaii or Diego Garcia. The proposed design is similar to the HSCT, powered by six afterburning turbofans, each producing 50,000 pounds of thrust. A delta wing with a span of 190 feet, and a platform area of approximately 6,900 square feet would be able to takeoff at 270 mph with a gross weight of 2.5 million pounds and a lift coefficient of 1.5. This includes the full weight of the SHAAFT and the 50,000 pound payload. The zero-stage launch platform carries all the low speed propulsion systems, in addition to the structure needed to support the gross weight of the SHAAFT with full payload capacity. The weight of the fully fueled zero-stage platform by itself is approximately 1.3 million pounds.

Global Reach/Global Power

To accomplish the "Global Reach, Global Power" objective, the second-stage vehicle, when coupled with the first-stage flying wing, will be capable of 14,000 miles of unrefueled flight at Mach 12. The second-stage vehicle, the SHAAFT, incorporates technologies developed for the National Aerospace Plane (NASP) program and waverider designs.

The fastest speed possible with hydrocarbon fuels is Mach 8. To achieve the speeds required by our missions' time constraints, we need to use cryogenic fuels. We chose to use slush hydrogen because of its higher density compared to liquid hydrogen, and the possibility of using the fuel in the active cooling process.

The SHAAFT will face high heating rates in the Mach 12 environment. An aerothermodynamically efficient vehicle having a hypersonic lift-to-drag ratio of 5, or better, will be a long, slender body with relatively small leading-edge radii (the nose radius, the cowl radius, and the wing leading-edge radius). The heating rates in these regions will be relatively high. Controlling the vehicle weight will have a high priority. Therefore, the development of high-strength, light-weight materials and the ability to use them efficiently for load carrying and thermal protection are high-priority items. Researchers at Ames Research Center (NASA) are developing advanced Diboride Ceramic Matrix Composites (CMCs), including Zirconium Diboride and Hafnium Diboride materials able to withstand repeated exposure to temperatures of 3660 deg F and of 4130 deg F, respectively (Rasky). Materials for thermal protection systems developed for Shuttle derivatives, for the NASP, for the X-33, and for the X-34 should be reviewed for possible incorporation.

The SHAAFT is 200 feet long with a wing span of 70 feet and an L/D ratio of 5. Based upon a 10,000 mile range at a Mach 12 flight condition, it was calculated that the SHAAFT would carry just under 940,000 pounds of slush hydrogen. Typical waverider designs (Ardema et al) have weight fractions close to 25% (that is, 25% structure, 75% fuel). The SHAAFT has a lower weight fraction of 16% since the zero-stage flying wing has a majority of the structure that is not required or useable at Mach 12. The SHAAFT weight fraction can be lowered to 16% because once the flying wing separates, the SHAAFT continues with its mission, carrying only what it needs from that point forward. The benefit of having a lower weight fraction is evident in the increased range possible at a given L/D ratio. The total weight of the SHAAFT including fuel and payload is approximately 1.1 million pounds.

In-Theater Dominance

In addition to serving as the weapons to be launched from the SHAAFT, the cruise missiles would have many uses in the case of protracted hostilities. The SHMACs would be sized so that two could be launched from an F-15E or other conventional aircraft. Because the SHMAC has a range of 1000 to 1400 nautical miles, the SHAAFT or a conventional aircraft would be able to remain well out of the range of most defense systems. Furthermore, the hypersonic capabilities of the SHMAC accommodate its use against time critical, moving targets. Since the applications of the SHMAC include missions where it is launched from a carrier aircraft at high subsonic speeds at an altitude of 35,000 feet, additional power would be required to accelerate the missile to hypersonic speeds and high altitudes. The initial acceleration from the subsonic speeds could be accomplished by a rocket located within the dual-mode ramjet/scramjet combustor flowpath. After the rocket fuel has been expended, the rocket casing is ejected.

Since the SHMAC is a weapon that can be used with conventional aircraft, thus deployed to forward bases around the world, simplicity of operations is a driving factor in the design of this weapon. The handling of cryogenic fuels under these conditions would introduce undesirable operational complexities and expense, which could be avoided with endothermic hydrocarbon fuels. However, the maximum Mach number possible with these fuels is 8.

Three distinct versions of the SHMAC will be developed for launch platform diversity: high-speed air launched, low-speed air launched, and surface launched. The high-speed air launched category includes all hypersonic delivery platforms. The SHAAFT will deliver ten (10) SHMACs designed for high-speed launch. The low-speed air-launched category includes current and future transonic attack aircraft. Existing aircraft which could launch SHMACs include the F-15E, F-16, F-14, B-1, B-52, F-111, P-3, S-3, and the B-2. The surface launched category includes both ship launched missiles from a standard Navy Vertical Launch System (VLS) tube, as well as ground launched missiles from a mobile or fixed launch platform.

The missile configurations for the high-speed air launched and the low-speed air launched are virtually identical. Both have the same dimensions; the difference is the additional weight associated with a rocket in the low-speed air launched version. This additional weight reduces

the payload capacity of the SHMAC. The high-speed air launched version has a payload capacity of 1000 pounds, all other versions are limited to a 500 pound payload capacity. In order for the system to be employed through a VLS, it must be modified. The missile is longer and more slender in this configuration because of the confines of a VLS tube. All versions of the SHMAC use a modular payload design. As a result, the SHMAC has the ability to change payload depending on the intended target. Payloads vary from high explosives to smart submunitions.

Access to Space

Any nation that possesses the ability to launch nuclear weapons into space poses a serious threat to the C³I operations of our armed forces. A relatively small orbiter, roughly the size of the Black Horse (Zubrin and Clapp) or an F-15, could replace the HCMs carried as the payload of the SHAAFT. Using multistage concepts similar to the Beta (Gord et al) or the Saenger (Grallert and Vollmer), the flying wing and the SHAAFT would deliver the orbiter to initial conditions for its "*Access-to-Space*" mission.

The SCREMAR is an aerothermodynamically designed TAV/orbiter that piggybacks aboard the SHAAFT to a release point of Mach 12 at 100,000 feet where it then separates and uses two rocket engines to boost it to orbit. The SCREMAR is 66 feet in length and has a total wing span of 40 feet. Gross vehicle weight is 50,000 pounds. The wings are fairly short, only 7 feet long each with a slight anhedral, but rounded underside to produce a detached shock wave during reentry. Studies could determine whether having the SCREMAR piggyback on top of the SHAAFT (as considered for this report) or having it stored inside or underneath the SHAAFT, similar to the Beta concept, would be most beneficial. The SCREMAR can carry a 3,000 pound payload to orbit, roughly the size of three 6 feet x 6 feet x 6 feet, 1,000 pound satellites. With a modular cargo bay integration, payloads could vary from tools to satellites to weapons systems. Upon returning to the atmosphere, it would be able to land at any conventional runway. Versions could be developed for both piloted and unpiloted vehicles

Two rocket engines would provide sufficient thrust to get the spacecraft to orbit. In addition, various thrusters along the body could enable the SCREMAR to maneuver in orbit. Roughly 75% of the gross weight would consist of fuel loaded throughout the entire body. The only areas that would not contain fuel would be the cargo bay, cockpit, and the nose forward of the cockpit where all of the electronics would be placed.

Use of the Proposed Weapons System

Considerable savings can be realized through the elimination of the constant forward deployment to provide a "*presence*" of United States Armed Forces. For those regions of the world where our forces do not have a permanent presence, deploying forces for a regional conflict is very expensive and time consuming. Recall that *Desert Shield* took longer than *Desert Storm*. It is also not likely that a future adversary will leave a nearby base infrastructure in place and allow us the luxury of several months to build up our forces. The savings could pay for most, if not all, of the design and development costs for the proposed weapons system.

The weapons delivery system (the flying wing and the SHAAFT) could also serve as the *first stage* of a multistage access-to-space system. We assume that the Armed Forces of the United States will have a constellation of satellites in place. At the outbreak of hostilities, the military leaders may identify the need for additional satellites or the repair of existing satellites. The Armed Forces of the United States have become very dependent on military/commercial satellites for communication, navigation, and reconnaissance. The elimination of a significant fraction of these assets could paralyze our C³I. Rapid replenishment of lost assets would be critical to the success of our military operations. The SCREMAR could be used to replace the satellites. Similar to the Beta System or the Saenger, the two elements of the *first stage* would carry the SCREMAR to its launch point. The flying-wing/SHAAFT combinations take the SCREMAR to Mach 12 at 100,000 feet where it stages. It achieves low earth orbit and completes its mission. We envision that the flying-wing/SHAAFT/SCREMAR system would be used during peacetime to place military satellites in space, to repair and to reposition military satellites. The SCREMAR could also perform antisatellite warfare (ASAT) should our adversary also have space assets. It could also deliver strategic, suborbital weapons or serve as a space-based laser (SBL) or airborne laser (ABL) platform.

Technology Considerations

Numerous technological challenges will have to be met before the proposed integrated hypersonic weapon system can be built. However, none of these challenges presupposes a breakthrough in technology. The zero-stage flying wing has a maximum Mach number of 3.5 which is slightly above the Mach number for the current (HSCT) design, but it should not be difficult to solve the problems unique to this application, e.g., the higher Mach number environment, command and control of a large supersonic UAV, given that the proposed system would be fielded in the twenty-first century.

The design of the SHAAFT offers the greatest challenges because there are no vehicles that have flown at sustained hypersonic speeds while powered by an airbreathing system. Furthermore, the aircraft should have global range with a payload of 50,000 pounds. The use of a flying wing to transport the SHAAFT to the one-third point of its global range at Mach 3.5 simplifies the design of the SHAAFT. Since the flying wing will carry the fuel required for takeoff, acceleration, and flight to the one-third point, the weight of the system will be much less. The SHAAFT won't need heavy landing gear to support the take-off weight of a zero-speed or a low-speed propulsion system. A dual-mode ramjet/scramjet combustor (Curran et al) could accelerate the vehicle from Mach 3.5 to its cruise Mach number of 8 or of 12. The decision to limit the vehicle to Mach 8 flight or to extend to Mach 12 flight depends on the propulsion system. Using endothermic hydrocarbon fuels limits cruise speed to Mach 8. Cryogenic fuels can extend the maximum cruise speed to Mach 12. Based on the desired survivability and range of the SHAAFT as a global platform, Mach 12 flight would be preferred. Based on desirable ground operations, endothermic fuels would be preferred. In any case, a trade study is needed.

Major problems facing designers include the determination of boundary-layer transition criteria and the complex viscous/inviscid interaction associated with the multiple shock waves

that occur when the payloads are released from the SHAAFT. The problem of developing boundary-layer transition criteria challenged the developers of the first reentry vehicles; it challenged the developers of the NASP; and it will challenge the developers of the SHAAFT. However, the problems should be solvable.

Technological developments will be needed in the areas of guidance, navigation, and control (GN&C) and sensors for both the SHAAFT and SHMAC. Large changes in weight and in weight distribution will occur during the flight of the SHAAFT. Control of an aircraft flying at hypersonic speeds over great ranges requires advances in the state-of-the-art. The design of the SCREMAR should make use of access-to-space programs around the world, as well as U. S. programs. Since the SCREMAR operates similarly to the Space Shuttle once separated from the SHAAFT, it should use as much of the current Space Shuttle technology as possible.

The technology programs used to develop the SHAAFT can be transferred directly to the SHMAC and SCREMAR, and vice versa. This is another application of the term *integrated* weapons system. The development of the S^3 concept as a single weapons platform with several similar and fully compatible vehicles will be much easier on the technology demands as well the development costs than attempting to fulfill the same roles with different weapons systems.

Conclusion

The United States needs a flexible, robust, and easily executed capability for global reach/global power and for access to space. The SHAAFT would serve as a mobile platform for deploying a wide range of assets. The SHMACs would destroy key targets, including space ports, communications centers, time critical targets, etc. The SCREMAR would serve the many applications that require access to space. Thus, the S^3 system can perform Counterspace tasks for Aerospace Control, tasks of Strategic Attack, of C^2 Attack, of Interdiction for Force Application, Aerospace Replenishment and Space Lift tasks for Force Enhancement, and On-Orbit Support. It is important to note that most of the technologies used in the design of the S^3 weapon system have already been or are in the process of being developed.

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Information Technology for Language Acquisition

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This paper provides an overview of initiatives for Information Technology and Language Acquisition with a focus on opportunities at the USAF Academy. The Internet and the World Wide Web provide cadets with limitless repositories of data, but the plethora is overwhelming. Intranet and CD-ROM can take the worry and wait out of the Web, supplying learners with appropriate multimedia archives and increasing time on task. Such resources will form orderly archives to enhance language acquisition worldwide. Standards set forth by national language-teaching organizations have learners connecting with others around the world to compare cultures and communities. Workshops at the USAF Academy have created online resources that illustrate the goals of the standards. Empowered students can create their own "Real Realities" with their counterparts in distant climes. Moreover, this team concept will enable disadvantaged students to participate on an equal footing.

Second language acquisition is one of the most promising areas of Education in the Information Age. Information technology is revolutionizing how second languages are taught. Analog technologies (e.g., interactive videodisk) already provide high fidelity simulations using authentic footage filmed on location (e.g., Paris, Madrid, Moscow, Munich) with a modicum of learner control and interactivity. The Information Age, however, will bring learners around the world together in online virtual classrooms, in a "Real Reality" that will far exceed current renderings of artificial environments. Preceding and supporting this "Real Reality" which will transform how students interact with their learning materials are the Internet and World Wide Web, browsers, Intranets, CD-ROMs, Virtual Schools, the Worldwide Language Improvement Project, and Common Gateway Interface (CGI) scripts.

This paper focuses on current initiatives and their immediate potential. The changes in information technologies that we expect in the near future are so mind boggling that one ends up in scenarios reminiscent of *Star Trek*, with learners being "beamed together" from around the world to participate in virtual classrooms. Actually, such virtual instruction (in the form of video conferencing) is already an avowed goal for the year 2000 of several elite universities in the US. Because current Air Force regulations require firewalls that eliminate many of the information opportunities that our civilian counterparts consider commonplace, this paper will concentrate on current facilities at the Air Force Academy along with possibilities available to students and faculty members who are subject to stricter controls on information than at most institutions of higher learning. The Language Learning Center (LLC) at the USAF Academy is currently regarded as the one of the finest in the world. With its 100 networked workstations, each having a videodisk player for displaying analog video, it represents an apogee of analog technology. A key to future of the LLC will be the integration of digital technology, for the foundation of Education in the Information Age is data in digital form, and the greatest repository of such information will be Intranets and the World Wide Web.

Internet, World Wide Web, Browsers

The Internet was begun 1969 as an experiment by the Department of Defense's (DoD) Advanced Research Projects Agency to have a communications systems that would survive nuclear attack. The basic idea was for packets of information to be routed freely from network to network until these packets reached their final destination. DoD sponsorship was eventually

replaced by the National Science Foundation Network. However, few foresaw the popularity of the Internet brought about by the World Wide Web. Now, a click of a mouse quickly takes learners to authentic information stored in distant corners of the world. Browsers (e.g., Netscape, Microsoft Explorer) are the software packages for browsing or surfing the Web. Unfortunately, the cornucopia of the Web is overwhelming. Moreover, the Web has also become largest repository of easily accessible pornography that the world has ever seen. As a consequence, susceptible learners frequently succumb to the siren song of cybersurfing, spending precious hours online but not on task. There are, however, some simple tools and techniques for enhancing learning and taking the worry and wait out of the Web.

Intranet/CD-ROM

An Intranet is a relatively inexpensive way to increase access to desired resources. An Intranet is constructed by attaching a hard drive to a Web server that admits only local users. Restricting access to local users has advantages. For example, Georgetown University Press has granted the USAF Academy permission to digitize the audio cassettes to its new Arabic program and to disseminate the resulting files over Intranet at the Academy, permission that would not be granted for wider dissemination. In a just few months, 2d Lt Oliver Erickson, an Academy graduate in Political Science waiting to begin flight school, was able to digitize all of the Arabic audio cassettes and create an index in HyperText Markup Language (HTML) for effortless reference to every page and exercise in the workbooks from Georgetown. He copied these files to a hard drive on our Intranet, generating a resource that has revolutionized learning Arabic at the Academy. Georgetown has permitted the Academy to share this resource with the Military Academy at West Point.

Success with Arabic is mirrored by efforts in other languages. The Academy has an agreement with McGraw-Hill permitting the Academy to develop interactive courseware to enhance the new Russian program, *Nachelo*. At Dartmouth, the Director of Humanities Resources is turning video clips obtained by the Academy from the Consulate of the People's Republic of China into a digital video library for global users. Similarly, under Academy supervision, native speakers are recording and digitizing basic sentences required for Arabic, Chinese, Japanese, and Russian.

Although Intranet resources present definite advantages over traditional audio cassettes, there are problems. Cadets complain about servers being down, and about the locations and addresses of archives changing without notification. Fortunately, CD-ROM offers a solution so uncomplicated that 2d Lt Erickson was able to master a CD that will be replicated and distributed to cadets at the Academy along with cadets at West Point. Of course, transferring data to CD also overcomes one of the serious limitations of multimedia on the Web, the lack of bandwidth. Transferring digitized graphics, sound and, most difficult of all, video, over the Web calls to mind such metaphors as pushing an elephant through a garden hose or sucking Niagara Falls through a straw. Transferring these files to CD provides an interim solution until the arrival of Digital Versatile Disks, which will have more than 10 times (projections range from 9 to 18 gigabytes) the storage of a current CD, and hold full-length movies in digital form.

Information dissemination via Intranet or CD-ROM overcomes another drawback of the Web: its ever changing addresses. Excellent archives available one day may be gone the next, and instructors who generated lessons or assignments dependent on these resources are left without. Not to worry, for wily Web developers have produced inexpensive tools, like WebWhacker by the ForeFront Group, that make it easy to download Internet repositories and store them locally.

For example, the USAF Academy cadets learning German were required to purchase the text, *Facts about Germany*, at a cost of about \$25.00 per cadet. The contents are the property of the German government, but the Chief of the German Division at the Academy convinced the German Deputy Minister for Culture to make this book available on the net as a resource for Germanophiles worldwide. With the data online, 2d Lt Erickson quickly extracted files from the Web. Now, cadets can retrieve excerpts from this resource stored on the Academy's Intranet, a process that will become more reliable when the files are transferred to CD-ROM for direct retrieval. As a bonus, the electronic version contains sound files not available with the paperback book, enabling cadets to listen to authentic German speech and songs online. Replacing this traditional text with an electronic archive results in an annual savings of about \$5,000. As a noteworthy aside, the German government has expended significant funds each year for the last several years to have a CD version of *Facts about Germany* developed using an authoring language. This version only runs in an IBM environment. Based on extracted Web archives, the CD created overnight by 2d Lt Erickson is multiplatform, compatible with IBM, Macintosh, and Unix machines.

As the files (including graphics) for a book can be downloaded from the Web for local storage, so can authentic materials depicting foreign cultures, a vital component of every language course. All language learners should be exposed to basic situations and cultural nuances in their countries of study. Once more, the Web supplies a treasure-trove of up-to-date resources, which may be archived locally for permanent availability. For instance, the advertisement for a picturesque German restaurant with graphics illustrating its scenic location now resides on the USAF Academy Intranet. Moreover, such repositories will be distilled from the Web for basic themes and situations (families, homes, schools, free time, cities, food, travel, vacations, etc.) across languages. Instructors can select authentic materials to fit with their overall programs, often much better than traditional books of readings have done in the past. In addition, negotiations are underway with national organizations (e.g., American Association of Teachers of German, AATG) to have such resources (German situations, themes, and culture on CD-ROM) made available to teachers worldwide.

Standards and Virtual Schools

Another opportunity proffered by the Web is to have learners around the world communicate with one another to compare their respective cultures and communities. This corresponds to the Standards established by the American Council on the Teaching of Foreign Languages (ACTFL) and other national organizations like the AATG. These Standards generally depict the following five concepts as five linked circles (reminiscent of the Olympic rings): Communication, Cultures, Connections, Comparisons, and Communities. With the

Virtual Schools Project, the USAF Academy's Department of Foreign Languages has assumed a leadership role in integrating information technology with these standards. Moreover, teachers and students from high schools throughout the state of Colorado have traveled to the USAFA for workshops on Web basics. These sessions, ranging from an afternoon to a full day in length, were led by 2d Lt Kevin McGowan and 2d Lt Oliver Erickson and conducted in Networked Classroom Laboratory (NCL), operated and maintained by Ms. Carolyn Dull of the Academy's Center for Educational Excellence. Their enthusiasm and support have made this initiative such a success.

As proof of the project's international recognition, the Director of the German American Partnership Program (GAPP), Dr. Wolfe-Manfre, sponsored the travel of 20 teacher-student teams from Colorado and surrounding states for a Web Weekend. Underscoring the importance of the workshop nationally was the attendance Ms. Elizabeth Hoffman, President-elect of ACTFL, and Ms. Helene Zimmer-Loew, Executive Director, AATG. Before this weekend, only five of the 700 schools in GAPP had a presence on the Web. Each of 20 teacher-student teams was successful with its assignment. As a result, the number of schools in GAPP with homepages quadrupled in a single weekend. Furthermore, 2d Lt Erickson generated a CD of these archives, which Dr. Wolfe-Manfre now presents to school administrators, teachers, students, and parents across the United States and in Germany. This remarkable set of homepages testifies to the productivity of teachers collaborating in partnerships with gifted students to integrate information technology in language instruction. Notably, this Web Weekend Workshop marks the first initiative of the ACTFL, the AATG, or GAPP to form teams between teachers and their empowered students for incorporating the wealth of the Web into classroom teaching. The weekend was conceptualized and conducted by two second lieutenants awaiting flight school.

This project has not been limited to workshops in the NCL, for 2d Lt McGowan has personally traveled to high schools around the state and worked directly with teachers and students in their own schools (e.g., Liberty, Air Academy, Coronado, Standley Lake). A highlight of his exertions is the success of students at Harrison High School, who attended a workshop in the NCL and then were having problems in their own computer laboratory. 2d Lt McGowan made several trips to the school and reportedly wouldn't leave the laboratory until it was up and running. Several weeks later, these students gave an acclaimed workshop for teachers and administrators from the several school districts.

Underscoring the significance of this accomplishment is that Harrison has the lowest per capita income of any high school in Colorado Springs and the highest percentage of minority students. In essence, the Virtual Schools Project is helping President Clinton build his oft touted bridge to the 21st century and is improving education by increasing the access to information. Similarly, virtual bridges are being built by the disadvantaged of our society, empowered by technology to improve their opportunities for success in our future information economy, a special concern of Vice President Gore. Because the Virtual Schools Project dovetails so nicely with the avowed goals of the President and Vice President, several VIP's visiting the USAF Academy have sent reports of the these activities back to colleagues in Washington, DC with connections to the White House. Increasing the chances for success of the Virtual Schools Project is a consortium with Colorado Department of Education (CDE) and several universities

in Colorado collaborating to improve language acquisition worldwide.

The Worldwide Language Improvement Project (WLIP)

Beginning with German organizations, we are working with foreign governments and institutions to make their learning materials available to learners globally. For instance, the German Information Center (GIC) made available 50 slides encapsulating the Fall of the Berlin Wall and the ensuing Unification of Germany. Helping the GIC and the German government commemorate the Fifth Anniversary of German Unification, Mr. Charles Elms (USAF Academy) digitized these slides in less than 24 hours. The slides were then copied to the Academy anonymous file transfer protocol site (ftp). At the University of North Carolina, Greensboro, the acclaimed Webmaster, Dr. Andreas Lixl-Purcell developed a series of online exercises founded on the graphics stored at the Academy. Under Academy contracts, Dr. Lixl-Purcell has produced Web workbooks for basic German and for more advanced topics, and this Web site is frequently included in reviews detailing the finest the Web has to offer for Germanophiles as well as for language acquisition in general.

Based on these achievements, Dr. Evelyn Donnelly of the CDE persuaded governmental organizations in France, Japan, Taiwan, and the People's Republic of China to provide authentic materials for digitization and inclusion in a Web repository that would support a curriculum for language teachers globally. Assisted by these commitments, CDE successfully applied for federal funding to support digitizing these archives and developing organized repositories for language acquisition. What's more, students and teachers at Harrison High School possess the skills and motivation to scan these archives and to produce basic homepages, whose accuracy will be insured by computer scientists, experienced educators, and native speakers at the USAF Academy. In essence, a team has been put in place that connects disadvantaged yet empowered students with organizations from Berlin to Beijing and enables these students to generate orderly, authentic repositories that will enhance language acquisition worldwide.

Common Gateway Interface (CGI) Scripts

Regardless of technology, language students must acquire fundamentals and their mastery must be checked. Fortunately, the Web presents a welcome solution to this problem too: Students can do exercises written in CGI scripts; and their responses provide feedback. These scripts can provide detailed records of performance as well as time on task. They provide invaluable data about how students have spent their time.

Designing Tomorrow's Engineers

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The end of the Cold War has ushered in a period of revolutionary change. In the words of a recent study, "*Not only is the world relying increasingly on technology for economic growth and job development, but the nation is making the difficult transition of refocusing a significant amount of its technology investment from national security to international economic competitiveness.*" In order to properly educate this country's future engineers so they will thrive in this extremely competitive global marketplace many leaders in academe, industry and government believe we must make fundamental changes in the engineering education enterprise. This paper surveys the common themes resulting from these important studies, including the monumental changes that are proposed for the engineering accreditation process in the United States.

Oh, for the Good Old Days! A specific threat, or challenge, or problem, and then we could simply "tweak" our undergraduate engineering education programs to handle the latest issue: the lack of mathematical and scientific rigor in pre-World War II engineering programs, or a dramatic world event, such as the launching of the Soviet Sputnik satellite in 1957, or a precipitous decline in engineering enrollments, and so forth. However, I believe the end of the Cold War earlier this decade has produced an entirely different challenge, particularly for engineering education programs in the United States. The opening paragraph of the recently completed study by the American Society for Engineering Education, *Engineering Education for a Changing World* says it best:

We live in a time of revolutionary change. Not only is the world relying increasingly on technology for economic growth and job development, but the nation is making the difficult transition of refocusing a significant amount of its technology investment from national security to international economic competitiveness. At the same time, we view technology as important in helping solve many difficult problems, from creating environmentally-sustainable development and improving communications, to devising more effective and cost-efficient health care systems. (Baum 15)

The North American Free Trade Agreement (NAFTA) further complicates the equation. Now we must resolve issues of equivalent engineering education, experience, examination and licensing requirements so that our engineering graduates may have the ability to practice anywhere in North America.

Finally, the population demographics in the United States are changing. It is essential that we attract highly talented students with a wider variety of backgrounds and career interests—particularly women, under-represented minorities and the disabled—and give them all the opportunity to succeed.

Experiments in Engineering Education

In response to these needs, and in keeping with our American tradition of individualism, many engineering colleges throughout the country, including ours at the USAF Academy, have been experimenting with new curricula, new educational technology delivery techniques, and innovative ways to recruit and retain traditionally underrepresented groups. The National

Science Foundation (NSF) has been promoting engineering education experiments like these by funding, since 1990, a series of Engineering Education Coalitions.

The goal of this NSF effort is to “stimulate the creation of comprehensive, systemic models for reform of undergraduate engineering education” (NSF). Currently there are eight coalitions involving sixty educational institutions and industrial partners. The funding by NSF must be matched by the coalitions.

Each coalition is comprised of a group of engineering colleges organized around a common innovative theme. For example, the Engineering Coalition for Schools of Excellence and Leadership (ECSEL), comprised of the City College of New York, Howard University, MIT, Morgan State, Penn State, University of Maryland, University of Washington, has been focusing for the past six years on engineering design across the curriculum. The Synthesis Coalition (California Polytechnic-San Luis Obispo, Cornell, Hampton, Iowa State, Southern, Stanford, Tuskegee, Berkeley) has been developing an electronic database called the National Engineering Education Delivery System, or NEEDS, through which engineering professors across the country can share course materials electronically.

As the NSF Engineering Education coalition schools and other colleges of engineering experimented with both incremental and bold changes to the traditional engineering curricula, many educators worried that the Accreditation Board for Engineering and Technology (ABET) accreditation process would put an end to innovation. The ABET criteria, as now structured, are viewed by many as overly prescriptive. The current ABET General Criteria are 19 pages of fine print, and the program-specific criteria run another 22 pages. In fact, ABET criteria have earned the dubious distinction of being a “bean-counting” exercise, concerned only with adding up semester hours of math, science and engineering content. In addition, many industry leaders complained that ABET was not responsive to the new challenges essential to survival in today’s global economy. Industry wants engineers who are aware of concepts such as customer focus, continuous quality improvement, and environmental sensitivity...engineers who can tackle an ill defined design problem, who are good communicators, and who can work effectively on a team.

In response to these concerns, ABET established, in 1992, the Accreditation Process Review Committee (ARPC) to “advise on how to increase flexibility in the engineering accreditation criteria while maintaining a strong emphasis on educational quality; and to suggest ways to make it easier to recruit outstanding engineers from industry and education to lead the ABET accreditation process” (Vision).

Over the next two years the ARPC conducted a series of consensus-building workshops so that all stakeholders—engineering professors, department heads and deans, as well as leaders from industry and government—would participate in the process. These workshops identified three major barriers to change in the accreditation process: excessively detailed accreditation criteria, a user-unfriendly accreditation process, and the difficulty in attracting technically-active mid career professionals from the broad spectrum of the profession to serve as leaders in accreditation. The next step was to construct a new paradigm for engineering education accreditation (Vision).

While the ABET committees and workshops addressed these three barriers to change, a number of the professional engineering societies conducted studies on the future of engineering education. As one important example, in 1991, the National Research Council of the National Academy of Engineering created a Board on Engineering Education which conducted a series of hearings throughout the country in an attempt to create a consensus Vision for Engineering Education for the 21st century.

Engineering Education for a Changing

Another important study was conducted as a joint project by the Engineering Deans Council and the Corporate Roundtable of the American Society for Engineering Education. Entitled *Engineering Education for a Changing World*, this project evaluated recommendations of previous studies, combined them with the recommendations of a workshop conducted as part of the study, and then developed a short list of key action items for use by stakeholders in government, industry and academe (Baum 17). Since I had a small role in developing this study, both as ASEE president and as a participating member on one of the five study task groups, and because I believe the study nicely, and briefly, summarizes the changes we must make if we hope to graduate engineers prepared for the challenges of the twenty-first century, permit me to review several of the report's 16 Action items.

To me, the most important Action Item is the one on reshaping the curriculum to ensure graduates are prepared for the broadened world of engineering work. Here is what the engineering curricula of the future should include, in addition to a solid foundation of fundamental engineering topics:

- Team skills, including collaborative, active learning,
- Communication skills,
- Leadership,
- A systems perspective,
- An appreciation of different cultures and business practices, and the understanding that the practice of engineering is now global,
- Integrated, multidisciplinary knowledge,
- A commitment to quality, timeliness, and continuous improvement,
- An understanding of the social, economic and environmental impacts of engineering decisions, and
- Ethics (Baum 12)

Closely related to reshaping the curriculum is the study's Action Item on Lifelong Learning. Gone are the days when a new graduating engineer could expect a 35 or 40 year career with the same company or industry employer. A civilian engineer's career in the United States now resembles that of an Air Force officer: a move every 3 years or so to a new company, often with radically new engineering responsibilities. In order to survive, engineers must continually update their skills and education. The report recommends that engineering colleges, in collaboration with industry, develop innovative ways of providing continuing education to

practicing engineers by instituting non-degree, career-enhancing programs, perhaps facilitated by new communications technologies (Baum 12-3).

Another important Action Item addresses the issues of resource sharing and technology transfer. In the United States our current laws and traditions often make it difficult for private industry to cooperate effectively with federal agencies. The report specifically recommends that "federal agencies that fund research and education should explore ways of encouraging educational institutions, research organizations, federal laboratories and industry to share resources. To enhance technology transfer and industry-university partnerships, universities, industries and federal agencies should develop flexible and negotiable policies governing intellectual property rights" (Baum 13).

How are the Action Items of this report, and those of the related National Research Council study, being implemented? Much like the recommendations of the earlier landmark reports on engineering education, that is, incrementally by visionary deans of engineering, aided by other industry leaders and policy makers who recognize the wisdom in the recommended changes. Of course, in order for colleges to experiment with change, it may be necessary to be more flexible with accreditation standards. That is precisely the reason for the proposed ABET Engineering Criteria 2000 standards.

A New Paradigm: Engineering Criteria

In my opinion, the principal change, or what we might call a paradigm shift, from the old ABET criteria to the proposed ABET Engineering Criteria 2000 is a shift away from measuring course content to measuring outcomes. In other words, what should our engineering graduates be able to *do* with their engineering education after they graduate? The new criteria clearly address those skills and attributes needed by the 21st century engineer, as detailed in the recent ASEE and National Research Council studies.

The draft ABET Engineering Criteria 2000 is only 3 pages long and contains just 8 criteria. Gone is the prescriptive language of the current ABET criteria—such as the need for a 2-semester sequence in general chemistry or calculus-based physics, coursework in probability and statistics, a set number of humanities courses, and so forth. However, much of the general guidance of the earlier ABET criteria is retained. For example, the earlier requirement on faculty qualifications is retained, but the requirement for a specific minimum number of faculty is removed. Instead, the criteria simply state, "The faculty who teach in the program must be of sufficient number and have the competencies to cover all the curricular areas of the program."

Assessing Engineering Education

Assuming that the Engineering Criteria 2000 are accepted, how are colleges of engineering in the United States going to demonstrate that their graduates can do all these things? In other words, how will engineering colleges assess both their programs and the engineering attributes of their students and graduates? To answer that important question we have several parallel efforts underway.

First, a number of engineering colleges have volunteered to be evaluated under both the current ABET criteria and the new Engineering Criteria 2000. These schools include Worcester Polytechnic Institute in Massachusetts, the University of Arkansas, Montana State University, and others. The experiences of these colleges will greatly aid the rest of us in developing our own institution-specific set of assessment tools and techniques.

Second, early last year we created a Joint Task Force on Engineering Education Assessment to evaluate the state of higher education assessment activities and to propose a process which, we hoped, would result in a spectrum of assessment techniques appropriate to engineering education. The composition of our joint task force, and the non-prescriptive nature of our task force objectives and subsequent action recommendations reflect the diversity of engineering education in the United States.

Our final report, entitled "A Framework for the Assessment of Engineering Education" was published in the May-June issue of the ASEE Prism magazine, and is available on the ASEE homepage at <http://www.asee.org/>.

Of particular interest is the section of the report entitled Examples of Program Assessment Measures. This section contains a series of charts, in which each of the ABET Criteria 2000, particularly Criterion 3 concerning knowledge, skills and attributes of future engineers, is proposed for assessment by several assessment measures. Here is a partial set of possible assessment measures that should be considered:

- Student portfolios, including design projects;
- Nationally-normed subject content examinations;
- Alumni surveys that document professional accomplishments and career development activities;
- Employer Surveys; and
- Placement data of graduates.

One of the report's Action Recommendations is for ASEE to establish a clearinghouse for a nationally shared database on engineering education assessment measures. Such a shared database should allow us to properly assess the ability of our students and graduates to meet the ABET 2000 Criteria which, in turn, should ensure that our graduates thrive in the increasingly competitive global marketplace (Framework 20).

Engineers as Leaders

Several years ago we developed a set of seven educational outcomes for our Air Force Academy, outcomes that we expect every Academy graduate to achieve, independent of his or her major. With the exception of the last one, these outcomes are surprisingly similar to Criterion 3 of ABET Engineering Criteria 2000. Here they are:

- Officers who possess breadth of integrated, fundamental knowledge in the basic sciences, engineering, the humanities, and social sciences, and depth of knowledge in

an area of concentration of their choice.

- Officers who can frame and resolve ill-defined problems.
- Officers who can communicate effectively.
- Officers who are independent learners.
- Officers who can work effectively with others.
- Officers who are intellectually curious.
- Officers who can apply their knowledge and skills to the unique tasks of the military profession.

If you just change the word "officer" to "engineer," and reword our last educational outcome to say, "Engineers who can apply their knowledge and skills to the unique challenges of the global technological marketplace of the twenty-first century," I believe you would have an excellent set of educational outcomes for any undergraduate college of engineering. In short, just as every one of our Air Force Academy graduates are expected to be a leader, so should we expect every one of our future engineering graduates to be a leader.

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What Won't Change in Education
or
What Rabelais and Montaigne Have to Say About Learning for 2025

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With all that will be different—even revolutionary—in education thirty years from now, we need to pose the question: “What will *not* change in education?” To illustrate the point—and answer the question—let’s drop back more than 400 years and visit the thoughts of two Renaissance thinkers who had to address the complexities of their own Information Age. One was an eminent physician; the other, a distinguished public servant (lawyer, magistrate, and twice mayor of plague-ridden Bordeaux). What was important in education to these authors, both of whom had lasting influence on the subject, is still important to us: curriculum; pedagogy; fostering critical thinking; intellectual breadth and depth; applicability of what students learn; solving ill-defined problems. We’ll look at the future by studying the proposals Rabelais and Montaigne made in a century that was as exciting and upsetting as our own.

With the many things that will probably be different—even revolutionary—in education thirty years from now, we need to pose the question: “What will *not* change?” Are there certain principles honored by centuries of teachers and students that will still be important in 2025? I’ve suggested that we can speculate about the permanence of some tenets by a reading of two Renaissance thinkers, François Rabelais and Michel de Montaigne, who both commented extensively about education in their own time and whose thoughts are still valid. What was important to these sixteenth-century figures—curriculum, pedagogy, critical thinking, intellectual curiosity, the role of education as a preparation for life as well as for specific callings—are matters that bear continued review. Let’s speculate about the future by a look at the past, a view from another information age that was, in many respects, as complex as our own time.

Rabelais and Montaigne are not only products of the Renaissance, they frame the sixteenth century: Rabelais begins the era and Montaigne concludes it; Rabelais documents the joy of discovery, Montaigne, the necessity of managing information; Rabelais praises freedom, Montaigne cautions judgment. Both authors exercised traditional professions: after having passed a fairly uncomfortable stage as a monk, Rabelais became an esteemed physician; Montaigne, trained in law, served for many years as a magistrate and was twice elected mayor of Bordeaux. Both authors also wrote about education, Rabelais most notably in *Gargantua* and *Pantagruel* and Montaigne most specifically in his essay *Of the Education of Children* (I, 26).

François Rabelais (whose exact birthdate remains a mystery) was probably born about 1483 near Chinon (Touraine) and died in 1553. The son of a successful lawyer, Rabelais’s entry into the holy orders—first the Franciscans and later the Benedictines—is an unsolved puzzle, for his lust for learning overwhelmingly outweighed his quest for piety. He left the cloister definitively about 1527 and, after having studied both law and medicine at several universities, concentrated his work with the progressive medical faculty of Montpellier. He practiced medicine in various parts of France, but most notably in Lyon, and eventually became the personal physician of Cardinal Jean Du Bellay, whom he twice accompanied to Rome.

Because of his association with the cardinal, Rabelais was familiar with the influential of his time. Far from being a secluded contemplator, he espoused a freethinking that obliged him to

leave his own country at least once. Ironically, some of his most enduring commentary about religion, politics, and education come in a work he wrote hurriedly and frankly for money. In spite of the haste of its composition, *Gargantua* (1534) contains some of Rabelais's most thoughtful judgment on what an ideal education should be. He does this in two parts of the book: the adolescence of Gargantua and in the chapters describing the Abbey of Thélème.

Gargantua belongs to a family not only of giants, but of princes. His education is the education of a future ruler, hence the importance of both breadth of subject matter and lessons of leadership. As M. A. Screech comments in his lengthy study:

In propagating this humanist educational system Rabelais is both copying and rivaling the new pedagogical theories which many of the great and not-so-great humanists of his day had formulated; some were being published at this very time. Budé's treatise was published in 1532; Erasmus in 1531; Vivès's broad and attractively humanist ideas were widely available; so too were Melanchthon's and many others. These humanist systems (often indebted to ancient platonic educational theories) all had in common the determination to bring a young nobleman into an appropriately virtuous Christian manhood. (147)

The goal of Gargantua's education was, as in *The Republic*, to make him a wise philosopher-king. But Gargantua's first experience with learning is a corpse of the worst kind of tradition. His teacher, the Latinist Thubal Holofernes, is the antithesis of academic vitality—Holofernes dwells on self-serving paradigms, stresses rote learning, and portrays the leaden stuff of medieval tradition even down to the bulky portable writing platform and inkwell he carries with him. Under his tutelage, Gargantua simply regurgitates unprocessed knowledge. The several allusions to digestive waste in this section of the work are much more than gratuitous bathroom humor—it is the metaphor of Rabelais's strongest condemnation of an accumulation of knowledge that is just so much tripe. Realizing that his son will go nowhere with this kind of formation, the wise Grandgousier hires Ponocrates—whose name in Greek means “the powerful”—to engage Gargantua's mind in a more profitable enterprise.

Before beginning the new regimen, however, Ponocrates recognizes that it would be wise to let Gargantua continue in his accustomed mode for a few days, “knowing that nature does not endure sudden mutations without great violence” (55). He then “scoured out all the alteration and perverse habit of his brain” (55), so that his student could begin afresh. When Ponocrates does initiate his method in earnest, Gargantua wakes at four in the morning and while the servants rub him down, he hears a reading from the Holy Scriptures and is so moved that he often gives himself to a deep adoration of God. Gargantua then goes to “the private places to make an excretion of natural digestions,” where, surprisingly, his preceptor repeats what had been read to him, “expounding to him the most obscure and difficult points” (55). Rabelais's point in engaging the student's mind while attending to matters of the privy goes well beyond shock value. As a physician, Rabelais found all the body's functions a continuing cause for praise, but his real message in this context is that there should be no time lost from thinking or understanding.

Gargantua learns both "theory and practice" of the seven liberal arts and proves himself as able in the water as he is on horseback. His exercises in chivalry—indeed most of his exercises in the field—serve to prepare him for battle and to eventually serve as a general in his father's army. When the bulk of the day's activities are over, Gargantua returns to the house and, while supper is in preparation, he and Ponocrates repeat specific passages studied earlier in the day for further clarification. At last sitting down to a "copious and ample" evening meal, readings from earlier in the day continue "as long as seemed good." The rest of the evening meal is "taken up with good conversation, all lettered and profitable" (59). The table companions also sing, play instruments, and join with "lettered folk or those who had seen foreign countries"—in short, as Rabelais emphasizes, they have "a wonderful time" (59).

From his own experience, Gargantua would later write to his own son, Pantagruel, on the virtues of a liberal education founded on the classics, but grounded in the dynamics of the changing world in which he lives. The model of changing times and of institutional revolution, however, comes in the closing chapters of *Gargantua* where, as a recompense for the courageous defense of his cloister, Frère Jean receives from his grateful prince an abbey of an entirely new order: the Abbey of Thélème.

Scholars have debated the "meaning" of Thélème virtually since *Gargantua* hit the booksellers' stalls. The abbey has borne the judgment of (1) a revolt against traditional monasticism; (2) a utopia; or (3) a pipe dream, the product of the overworked imagination of one who knew the constraint of religious orders and simply wanted a way out (Frame 43). Thélème is very definitely (1), quite likely (2), and quite possibly (3)—it is also very probably all three in one. Thélème is often discussed in terms of what it does not have: no walls, hence it is an open institution; no clock, hence the residents are not bound by the traditionally rigorous schedule of the offices; it admits only the intelligent and the attractive (in opposition to the tradition of the cloister as a kind of dumping ground for social residue); finally, in place of the vows of poverty, chastity, and obedience, the Thelemites could be rich, married, and, most of all, could exercise their free will. None of this is as important, however, as the overriding presence of Thélème as an educational model.

In the education of Gargantua and Pantagruel, the tutor is the guiding force. In the new abbey, education is much more a self-directed project. The men and women—coeducation is also a key monument here—who live at Thélème have a choice of study rivalled only by their freedom to engage in it. The word "Thélème" comes from the Greek *thelemos* ("free will"), the same word that, in the Koinonia Greek of the New Testament means "the will of God" (Nykrog qtd. in Frame 41). The sumptuous physical plant of the abbey—perhaps a deliberate hyperbole to underscore the Rabelaisian revolt or a statement of the need to invest in education—would be the envy of any university today: spacious galleries and libraries filled with books in Latin, Greek, Hebrew, French, Italian, and Spanish; there are playing grounds, swimming pools, archery fields, and riding paths. Further, the young men and women who live and study there take frequent excursions into the neighboring park for on-the-spot lessons in botany and zoology; they also have recreational outings and picnics. Never had there been a more graceful or multitalented assembly: fluent in five or six languages, equally talented in reading, composition, and playing musical instruments; most importantly, however, they are as skilled in courtly

behavior as in all of their other pursuits. The Thelemites live in a world in which instruction is not separate from the rest of life, but intricately woven into every aspect of it. Most of all, however, they live by their single rule of “do what you will” because, as Rabelais puts it, “people who are free, well born, well bred, moving in honorable social circles, have by nature an instinct and goad which always impels them to virtuous deeds and holds them back from vice, which they called honor” (126).

If Rabelais describes education in terms of the necessity of freedom, a wide range of subject matter, and filling every minute of the day with useful activity, Michel de Montaigne leans more in the direction of the cultivation of judgment and application of object lessons. Montaigne concludes the sixteenth century in France by announcing the dawn of a new intellectual climate, one that, with the nascent scientific revolution, stands as the portal of the modern age. Born into a recently ennobled family of Bordeaux merchants who had earned their wealth in the wine and salt fish trade, Montaigne benefited from an education—outside of formal the schooling he detested—that was a model in itself. Montaigne's father put his son to nurse with peasants for two years, because he saw the need for a noble's son to understand the condition of the poor; he had his son roused to the tune of sweet music to mollify the shock of awakening; most of all, however, he hired a German tutor who knew hardly a word of French to teach his son Latin as his first language. (Montaigne's father also commanded the entire household to speak only Latin in the boy's presence.) As a result, Montaigne thought in Latin as a child and, on his arrival at the Collège de Guyenne, spoke and wrote Latin much better than his schoolmasters.

Montaigne's essential commentary on education appears in his first volume of essays published in 1580, most specifically in the essay titled *Of the Education of Children* (I, 26). The French title—*De la Nourriture des Enfants*—is closest to Montaigne's real thought that education is a nourishing process from which we draw strength and wisdom. Montaigne knew the value of both these attributes: as a magistrate and mayor, he faced decisions affecting other human beings frequently; further, he lived during the terrible religious wars that devastated France during the last half of the sixteenth century and would end only with the proclamation of the Edict of Nantes by Henry IV in 1598.

Some argue that Montaigne opposes Rabelais in his propositions by favoring select subject matter rather than plenitude. In many respects, however, Montaigne's is less an opposition to Rabelais's philosophy than a refinement of it. As in *Gargantua*, Montaigne's essay concerns itself with the education of a future leader, one who needs to know as much about human nature as about the world; the choice of tutor is again paramount, as the whole success of an education is, in Montaigne's judgment, the result of a good teacher. Ironically, Rabelais turns out to be more forward-thinking than Montaigne in at least the aspect of gender. Where the Abbey of Thélème offers both men and women equal access to learning, Montaigne targets only a young man. In spite of this shortcoming, Montaigne's essay is rich with what was—and still is—vital to education.

Montaigne wants his ideal student to be “an able man rather than a learned man” (*Essays*, I, 26, 110), therefore, one should choose a tutor with a “well-made rather than a well-filled

head," but, adds Montaigne, "that both these qualities should be required of him, but more particularly character and understanding than learning; and he should go about his job in a novel way" (110). Montaigne's lesson in pedagogy insists from the start that the best teachers must have discerning judgment, must be of good character, and must know the baseline experience of their students to lead them into greater complexity. In a lengthier comment, Montaigne complains of what the teacher-student relationship has become and recommends what it should be:

Our tutors never stop bawling into our ears, as though they were pouring water into a funnel; and our task is only to repeat what has told us. I should like the tutor to correct this practice, and right from the start, according to the capacity of the mind he has in hand, to begin putting it through its paces, making it taste things, choose them, and discern them by itself; sometimes clearing the way for him, sometimes letting him clear his own way. I don't want him to think and talk alone, I want him to listen to his pupil speaking in his turn. (110)

Montaigne quite clearly recommends a learner-centered education, adding that letting the student speak first is the Socratic method. Establishing dialogue between teacher and student provides the setting in which real learning can take place, for, he adds, "The authority of those who teach is often an obstacle to those who want to learn" (110). The good teacher knows how much and how fast a given student can learn: "It is good that he should have his pupil trot before him, to judge the child's pace and how much he must stoop to match his strength. . . it is the achievement of a lofty and very strong soul to know how to come down to a childish gait and guide it" (110). Further, the good teacher also knows how to adapt his lessons to the individual student's needs and abilities: "If, as is our custom, the teachers undertake to regulate many minds of such different capacities and forms with the same lesson and a similar measure of guidance, it is no wonder if in a whole race of children they find barely two or three who reap any proper fruit from their teaching" (110).

But the student should also be aware of the lesson's purpose and should be able to evaluate his own progress: "Let him be asked for an account not merely of the words of his lesson, but of its sense and substance, and let him judge the profit he has made by the testimony not of his memory, but of his life" (110). The ideal education, in Montaigne's judgment, is where learning provides an avenue to the larger arena of life itself. If what we learn does not prepare us for that challenge, education will have failed in one of its most important functions; likewise, if education does not involve a recognizable processing of the matter under study, the task will be incomplete: "It is a sign of rawness and indigestion to disgorge food just as we swallowed it. The stomach has not done its work if it has not changed the condition and form of what has been given it to cook" (111). Referring to the essay's very title (*De la Nourriture des Enfants*), Montaigne strikes the digestive metaphor to emphasize that education is nourishment of the mind as surely as taking food is nourishment of the body. What we acquire is only a borrowing, unless we transform what we ingest: "The bees plunder the flowers here and there, but afterward they make honey, which is all theirs; it is no longer thyme or marjoram. Even so with the pieces borrowed from others; [the student] will transform and blend them to make a work that is all his own, to wit, his judgment. His education, work, and study aim only at forming this" (111). The real test of education, Montaigne suggests, is how we use what we've learned without thinking

about it: "To know by heart is not to know; it is to retain what we have been given our memory to keep. What we know rightly we dispose of, without looking at the model, without turning our eyes toward our book" (112). Education's proof is what we can assimilate into daily life.

In all the student acquires, there is nothing more precious than an internally regulated ethical conduct. We are not very far from Thélème in Montaigne's thought that reverence of truth and personal integrity are companion virtues:

Let his conscience and his virtue shine forth in his speech, and be guided only by reason. Let him be made to understand that to confess the flaw he discovers in his own argument, though it still be unnoticed except by himself, is an act of judgment and sincerity, which are the principal qualities he seeks; that obstinacy and contention are vulgar qualities, most often seen in the meanest souls; that to change his mind and correct himself, to give up a bad position at the height of his ardor, are rare, strong, and philosophical qualities. (114)

Where might the ideal student acquire his information? From as far away as distant countries, says Montaigne, to as near as his own household: "Put into his head an honest curiosity to inquire into all things; whatever is unusual around him he will see: a building, a fountain, a man, the field of an ancient battle, the place where Caesar or Charlemagne passed. ... He will inquire into the conduct, the resources, and the alliances of this prince and that. These are things very pleasant to learn and very useful to know" (115).

The most useful attitude is the far-seeing one, one that is capable of imagining a world beyond the immediate one: "Socrates was asked where he was from. He replied not 'Athens,' but 'the world'" (116). Socrates' example leads Montaigne into the even larger metaphor of the world as the student's real open book. In a lengthy comment well worth citing in full, Montaigne resumes what is the essence of his philosophy of education:

This great world, which some multiply further as being only a species under one genus, is the mirror in which we must look at ourselves to recognize ourselves from the proper angle. In short, I want it to be the book of my student. So many humors, sects, judgments, opinions, laws, and customs teach us to judge sanely of our own, and teach our judgment to recognize its own imperfection and natural weakness, which is no small lesson. So many state disturbances and changes of public fortune teach us not to make a great miracle out of our own. So many names, so many victories and conquests, buried in oblivion, make it ridiculous to hope to perpetuate our name by the capture of ten mounted archers and some chicken coup known only by its fall. The pride and arrogance of so many foreign displays of pomp, the puffed-up majesty of so many courts and dignities, strengthens our sight and makes it steady enough to sustain the brilliance of our own without blinking. So many millions of men buried before us encourage us to not be afraid of joining such good company in the other world. And likewise for other things. (116)

What will not change in education thirty years from now? We would hope that the tenets of our two Renaissance authors would remain, but, even more, find a new vitality where

improvements in technology would make the essential task of learners coming to grips with learning an easier and more fruitful labor. Sir Philip Sidney defended poetry by saying that it combined the best of all processes: poetry teaches while it also delights, as cherry-flavored medicine is as beneficial as it is pleasant-tasting. If Rabelais and Montaigne had read the educational outcomes that we have adopted at the Air Force Academy, they would have applauded: they would have well agreed on the importance of breadth as well as depth of knowledge, the ability to frame and resolve ill-defined problems—for both knew ill-defined problems and sought how to resolve them, and the need to communicate effectively—Montaigne said, “The speech I love is a simple, natural speech, the same on paper as in the mouth; a speech succulent and sinewy, brief and compressed, not so much dainty and well-combed as vehement and brusque....not pedantic, not monkish, not lawyer-like, but rather soldierly” (127). They would have loved the proposition that the best learners are those who know what they know—and what they don’t—because they have become independent learners. At the same time, Rabelais and Montaigne would have recognized the need to work with others—their lives were a fitting testimony of that virtue—and the continuing reward of remaining intellectually curious. The founders of Phi Beta Kappa recognized that principle when drafting the society’s motto: “The love of learning, the guide of life.” In all these things, Rabelais, Montaigne, educators of the present and those of the future will probably agree that application of learning to one’s life and to one’s specific calling is the ultimate proof of its value. In the preface to *Gargantua*, Rabelais speaks with admiration of the philosophical dog who tenaciously attacks the bone until it at last yields its *moëlle substantifique*—the substantive marrow, nature’s most perfect food. It is a prize of substance well worth the effort. The student of 2025 will also need to keep cracking at obstacles until the hidden nourishment at last reveals its digestible power. Our task is to enable the chewing.

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The Future of Networked Learning

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This paper focuses on possibilities for collaborative educational experiences that will occur entirely or primarily through electronic communication. Learners will eventually be able to choose from a wide variety of educational environments with different degrees of interconnectivity and will have many opportunities to work and learn with others throughout the world. Implications of these electronic environments will be discussed.

Imagine this scenario: Learners in political science, ecology, and business classes are investigating the role of inventions over the past 400 years, and then using their information to predict new ways of planning cities to take advantage of population patterns, business activity, and environmental concerns. Learners are located in many countries and the three instructors are also geographically dispersed. Groups of learners use multiple interactive media to work together. Some of the activities occur synchronously and others asynchronously. At various times the learners are working via audio, video, computer program, data exchanges, graphical interactions, and shared text areas. Experts are contacted electronically; students determine resources they need, and interact with the instructors for guidance. The final product is then offered to the world as a possible solution to authentic difficulties.

This scenario is not too different from what is possible now. However, this level of interaction is not available to everyone equally, and most of the world does not have the necessary equipment. The technologies exist to accomplish this interconnectivity, yet they are seldom integrated into ongoing curricula and even less often used to reconfigure the learning environment. We have not yet seen a shift from the traditional model where educators talk about information, to a scenario where learners interactively construct knowledge from that information.

It is almost a cliché to talk about the massive amounts of information that current networks offer us. Whether using the global matrix, the Internet, the World Wide Web, or intranets, people today can find almost anything they seek. It has been said that in a very short time a fiber the size of a human hair will deliver every issue ever published of the Wall Street Journal in less than a second (Negroponte 1995). How might these changes impact education? In particular, what do we know about and how do we imagine online learning?

What is networked learning?

Over the next few decades, we know that technology will change so rapidly that it is difficult to imagine what any single activity will be like. Certainly networked learning will include media, accessible on demand, that incorporate a mixture of data, text, video, audio, illusion, assistant devices, and simulation. The information will flow downstream from a headend (central service station), as cable television does now. Additionally, information will flow upstream, so that every computer connected to a network will be capable of publishing information.

Individuals will be able to manipulate activities to fit their schedules. It will be easy to shift learning activities to accommodate the needs of busy professionals, family members, travel, or illness. Moreover, when things must happen at a particular time, such as a video conference, one's location will not matter, since plugging into the network will be possible from anywhere.

Interaction will be supported in other ways. Groupware, a new class of software, will assist in instruction and collaboration. Groupware refers to software that supports groupwork (Greenberg 1991). Use of groupware is in an embryonic stage, with examination of its potential focused in only a few areas. The use of networks and groupware as instructional tools has potential to enhance the nature and perceptions of interaction in network education.

What is the current status of networked learning?

This paper reports an exploratory research project that investigated the current use of online educational environments in higher education. From interviews and investigations, it is clear that the number and types of networked education are expanding with great rapidity. Indeed, the snapshot reported here may already be out of date by the time you read this paper.

Entire degrees are available electronically. Many institutions are eager to expand their student population base in this way. These degrees require varying amounts of time for meetings at a campus or central location. Degrees available electronically include Masters degrees in Business or Instructional Technology, PhD degrees in business, education and social sciences; most are designed to meet the needs of working adults.

Many individual courses are also available electronically. These courses represent a wide variety of formal, credit bearing courses—for example, standard undergraduate core courses, graduate courses in a variety of areas, and informal courses. Professional development education is also available. Many professional groups (e.g., nurses, veterinarians, emergency medical technicians, educators and social workers) sponsor interactive avenues for their members to obtain continuing education credits, update skills or practices, and maintain contact with others.

Educational opportunities also happen in more informal ways. Many people have taken the "Road Map to the Internet" mini-course, which accrues no credit, costs little, and provides little interaction with others. Its value is in serving precisely the task it sets out—to be a map for individual investigation.

Many educators are using electronic capabilities to enhance traditional courses. Some educators have created World Wide Web (WWW) pages where students can find assignments, activities, references, and supplementary materials. In other cases, professors use listservers and interact with students as a group. One science professor reported that his students considered his lectures and information more up to date because they were also located on the WWW.

Lessons from Literature

The traditional distance education literature focused on the implementation of correspondence, compressed video, or satellite broadcast delivery courses. That literature does provide some parallels, but it does not directly inform the design and development questions specific to online courses (Schrum 1995). A beginning effort has been made to describe the ways online education is developed, the needs of the students, and methods to assure the quality of the instruction and interaction (Harasim 1990; Hiltz 1990; Schrum 1992; Schrum 1995). Results of preliminary studies have suggested that online education is effective for well motivated students (Hiltz 1990; Levinson 1990; Mason & Kaye 1990), which coincides with research in distance and traditional education.

Online communications flatten hierarchies and increase work completed within organizations by focusing on message content, rather than social or personal characteristics of the messenger (Zuboff 1988). These findings have implications for education, as individuals are forced to consider their contributions, and one researcher found that, in addition to an increase in communication between and among participants, computer communication "acts as a heuristic device—it encourages students to assess their own work first" (Barrett 1994 120).

Further, online interaction appears to foster social and professional communities. I have looked extensively at online social interactions and concluded that as people take initiative for their own learning, a democratic social order evolves, and hierarchical systems no longer predominate (Schrum 1993).

Harasim (1990) summarized the characteristics of the online education that she investigated as place and time independent, many-to-many communication with real collaborative learning, and communications dependent on text. Other advantages this type of distance learning are both instantaneous and asynchronous communication, access to geographically isolated communities, multiple participants within activities, and cultural sharing among the people of our world.

The environment in which an online experience is constructed is significant to the development of the educational experience. According to Harasim, "Lessons gained over the past two decades of experience in network communication highlight the importance of designing the environment. Networked are the intersection of social and technical systems; design involves both technical and social considerations" (1993 29).

Learners report greater control and responsibility toward their learning. Students also find that the act of writing demands greater reflection than speaking (Rohfeld & Hiemstra, 1993). Several research and anecdotal studies have looked at online components of traditional courses and have concluded that these components substantially increase the communication between teachers and students and among students, when compared with similar classes without the computer communication component (Hartman et al 1994; Hiltz 1990; Schrum 1995).

Online experiences meet the needs of some students—those unable to attend a university that offers the desired course, those in remote locations or in gridlocked urban areas, those

already comfortable with computers, and those who prefer to work individually, or without time and location constraints. Equally important, networked learning can enhance the way learners work together, construct knowledge, ask questions, and evaluate activities. The characteristics and questions that emerge from this information can be used to help construct guidelines for making decisions about the creation of such courses.

Networked learning - What do we need to know?

There is a compelling need to begin a dialogue about this topic and to inform future learners, possible instructors, and institutions about the requirements for network educational experiences that are pedagogically sound. Currently no rubric exists to inform potential users about essential strategies for successful online learning. More important, one significant goal for researchers will be to determine the perceived strengths and weaknesses of the current practice, in order to understand this emerging field.

Creating a successful networked learning experience is not a trivial task. From the information gathered it is evident that certain pedagogical, organizational, and institutional issues must be considered when beginning this process.

Pedagogical issues include: identification of goals, philosophical changes in the teaching and learning process, reconception of the teacher's role, and redesign of the course delivery system. Instructors must make pedagogical decisions about fundamental goals. The salient questions when creating any educational activity have always been, "What are the instructional and personal goals for the students?" "What is the purpose of this activity?"

Once educators determine their goals, they must examine the philosophical changes that online learning requires. One instructor, who uses online components in all his classes stated, "I begin with two premises. First, active learning is a good thing. Second, bringing students into frequent contact with class peers, and world wide peers, promotes active learning. Basically my experience has been that electronic communication promotes active learning" (Smith, personal communication 1994).

The course designer may choose to redesign an existing activity or to create something new, but it would be unwise simply to drop that old activity into the new environment. The structure of the course, the planning for educational and personal needs, the teacher's role—all must be reconceived. The designer will have to determine what actions will promote active and independent learning. Further, adult learning theory indicates that relevant materials and negotiated assignments are helpful to ensure participation, involvement, and action necessary to meet these goals. It is essential to link personal experiences of the learners into the learning (Lauzon 1992). If collaborative learning is desired, it is useful to plan activities that foster student initiative, group discussion and reflection, and process writing with revisions (Eastmond 1995; Schrum 1995).

Organizational issues revolve around: timing, inclusion of face to face components (if possible), structure of group interactions, and minimum prerequisites for using networked

learning. First, a decision must be made regarding what proportion of a course will be electronic. Some of these courses are entirely online, others combine online and face to face activities, and still others have some combination of models.

Another organizational determination must be made as to the type of assignments and interactions that are to be included. These may range from group projects created and delivered online, process writing and interactions, or completely individual assignments. Other organizational issues must be considered. Group size may influence the communication patterns, but it may also impact the life of the teacher. Teaching online courses requires a great deal of time—to answer mail, to manage the data, and to respond to postings. Are extra tutors available to assist? Is it possible for a team of teachers to share the work?

Students must have some prerequisite skills. Individuals who have no experience with computers are less able to learn from electronic interactions since they spend enormous amounts of time completing the most basic of word processing tasks (Hiltz 1990).

Institutions, as they move into networked learning to supplement and even replace traditional learning, must address faculty issues including: faculty incentives, access and equity, credit decisions, ongoing evaluation, and continual support for students and teachers. Foremost, they must recognize faculty who take initiative in creating and teaching online courses. This recognition will need to be included in the promotion and tenure process. Institutional support for innovative practices is often nominally present, but time must also be available for research, design, and development.

Other institutional issues concern the amount and types of support available for distance learners. How will the students be supported in registration and transcripts, resource access and problem solving? Another question involves increased costs for equipment and access associated with online courses. Who will bear these costs?

Lastly, evaluation must be included in every learning activity. Have the goals been accomplished? Is the organizational structure appropriate and equitable? Did the institution offer the support necessary for students and for the educator? These and other questions can assist the administration in improving this new model for education.

Learners and Networked Learning—What Can We Conclude?

This paper was written to begin a dialogue on the future and current status of networked learning, to identify significant issues in the design and development of such activities, and to develop an understanding of the characteristics of learners who engage in this practice. It is important that the educational technology and research communities recognize this as an area of fruitful investigation.

With the advent of networked learning, educators must take the lead in assuring that these experiences are worthwhile for all learners, and that they are driven by educational goals. For too long technology vendors have driven the use of technological innovations in education. The

electronic community would benefit from an organized forum for sharing experiences and lessons as the number of networked learning experiences continues to grow.

The educational community must also make a unified effort to uphold the highest ethical standards in electronic research and practice. The future is exciting and the potential is unlimited; with a few thoughtful precautions, educational opportunities will expand to include all learners.

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Electronic Publication from a Scholarly Press Perspective

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National Defense University Press's aggressive program of electronic publishing has led to the selection of NDU's Home Page as one of the "Top 5 Percent on the Internet." This paper discusses the process of selecting, evaluating, and editing scholarly manuscripts, and then turing them into award-winning hard-copy and electronic publications. This year, the National Defense University and its Press are celebrating 20 years of excellence in joint professional military education and research in and publications of studies of national strategic importance. An arm of NDU's Institute for National Strategic Studies, the Press publishes the work of a wide range of experts, including the faculty of NDU, other academics, diplomats, military professionals, and independent scholars. Among the Press's publications available on the Internet are the annual Strategic Assessment, the Strategic Forum, position papers, the McNair Papers monograph series, the annual Essays on Strategy volume, and the various titles of the NDU Press books series.

The information revolution is making it possible for virtually anyone to publish his or her thoughts to the world without any censoring, screening, or gate-keeping. The rapid expansion of the Internet and its World Wide Web demonstrates the appeal of this new capability. Hundreds of new Web sites are added daily; gone are the days when Web readers were pleasantly surprised to find that a company or other institution had a Web page; now, they are annoyed when a desired product or service fails to have one. Meanwhile, readers and publishers are searching for ways to control, filter, or interpret the mounting mass of information.

Role of the Scholarly Press in the Information Age

In the age of the codex book, publishing houses—such as university presses—performed the screening service that enabled readers to avoid the dross and find the kinds of texts and information they needed, confident that the products of the scholarly presses met certain minimum standards for usefulness of information and quality of writing and editing. The large number of such presses, combined with the principle of freedom of the press, reduced the chances of undue censorship that might develop in any screening system. What kind of comparable gate-keeping will emerge in the new information age to help readers sift through a fast-growing accumulation of unmediated information?

Happily for those in the publication business, one key gate-keeper will continue to be the scholarly press. Following a period of wariness about the new medium, dozens of university presses and other publishing houses have launched electronic publishing programs. First came Web sites from the presses' marketing departments advertising new books, publishing catalogs, and making ordering a simple e-mail procedure. Some presses, notably some government organizations like NDU Press, Air University Press, and other affiliates of the Government Printing Office (which had no profit incentive due to the fact that many of their publications are in the public domain, and thus have no mechanism for making or losing money via the Internet) began to publish electronic versions of their hard-copy books. Later, certain presses began to experiment with e-publication of scholarly journals. The Johns Hopkins University Press's *Project MUSE*, for instance, now offers libraries subscriptions to more than 40 academic journals in electronic form. So far, they are finding that not only are the e-journals selling well, but they are also seeing a rise in the number of subscriptions to their print journals as well. Another

similar example is *The Chronicle of Higher Education*, which offers a two-tiered Web site: casual browsers can access abstracts of articles in the current issue of the weekly newspaper, while individual subscribers are rewarded with password-controlled access to an electronic version of the full text of *The Chronicle* for the past eight years, together with daily news abstracts sent to each subscriber's personal e-mail box. New electronic-only journals are also being launched. University College, Cork, in Ireland, is developing *Chronicon*, an "electronic journal of international history" publishing "peer reviewed articles." A feature common to the several new electronic-only journals is their prominent announcement of their juried, or peer-review procedures. More innovations are bound to come, especially once a secure mechanism for paying for e-publications can be devised.

While scholarly presses struggle to cope with the emerging technology—deciding whether to publish in paper, electronically, or both—other questions are being raised by the new medium, especially in terms of the various kinds of electronic texts.

Structure of E-Texts

Beyond being written clearly and obeying certain rules of language, electronic texts must also be encoded and "tagged" so as to be viewable by CD-ROM readers or by readers on the World Wide Web. The most common coding system for the Web is known as Hypertext Markup Language, or HTML. This code allows the electronic editor to mark—or "tag"—certain aspects of the text (e.g., bold or italic) to ensure that any viewer of the projected page (whether on the Web or on an individual CD-ROM-reading computer) will see the text as the editor wishes it to be seen. HTML also allows certain features of the text to be more easily searched.

The HTML system is the simplest form of code falling under the broad umbrella of the Standardized General Markup Language (SGML), which contains the basic procedures for establishing various specialized e-text encoding languages. In between these extremes are the two forms of the Text Encoding Initiative: TEI and TEI-Lite. TEI and its simpler cousin offer many more options for tagging aspects of the text, including: personal names, places, genres (verse, prose), languages (e.g., Latin or French phrases in English-language texts), and alternate spellings. A TEI-tagged e-text thus offers the reader many more opportunities for creative searching, and so a more useful text.

Many e-text experts expect the Web to move in the direction of TEI tagging, promising not only better e-texts, but also demanding much more and different editorial work for the presses that produce them. Now, in addition to the traditional editorial work of shaping a manuscript into a publishable product on paper, the press must also employ experts to tag the result to prepare it for electronic publication.

Types of E-Texts

Ever since the development of movable type in the 15th century, words deemed worthy of printing have held a special status in Western society. The effort and costs of typesetting and printing tended to mean that the product of the printing press had undergone a certain measure of

evaluation. Further clues to the value of the printed text were provided by the quality of the paper and bindings. Although very far from fool-proof, even these simple clues are absent in the new electronic medium. Furthermore, unlike printed paper, the electronic text is both infinitely editable and potentially evanescent: e-texts can be changed daily or deleted almost without trace. These new possibilities and problems demand new ways of thinking about e-texts.

The new medium is a boon to two types of texts especially: very large archives and time-sensitive information. For instance, the electronic searchability of the massive *Oxford English Dictionary* has made a whole new approach to language study possible, and on-line college catalogs provide students with up-to-the-minute guidance on course offerings and programs. Beyond the uses to which e-texts may be put, the products of publishing houses and other sources of authoritative e-documents (such as university e-text centers and special collections departments) may also be divided into at least three other categories: Ephemeral, Evaluated, and Electronic-only.

Ephemeral E-Texts

Not to be confused with time-sensitive texts, ephemeral e-texts are those that are published without the customary level of review given to the kinds of texts that, under the old print regime, would have merited publication and distribution. Among these texts are student papers, works-in-progress, and unedited conference proceedings. The ease of electronic publication encourages people to think of e-publication as tantamount to the photocopying and distribution of such works to classes or participants. A problem with such thinking is that Internet publishing has the potential to distribute such texts to a far larger audience than even the largest print run of a major commercial publishing house.

The desire to disseminate all manner of ephemeral texts via the Web is further encouraged by the apparent intimacy of the computer environment. It is easy to imagine that texts meant for distribution within a single course at a college will be viewed only by those concerned, when in fact hundreds of thousands of people have ready access to such potentially undigested material. Furthermore, increasingly powerful search engines are making it possible to find unadvertised texts, ones that the e-publisher might not have expected to be of interest to others. Downloading, printing-out, and quotation of such ephemeral material may result in unintended damage to, say, a student whose draft paper winds up being reviewed by a scholarship committee member, when it is not up to a standard that he or she might wish. As the population of Web readers balloons beyond the eight percent who now have access, these issues will become even more important.

Evaluated E-Texts

Much closer to the traditional products of publishing houses, evaluated e-texts are those that have undergone a full course of editorial review, expert evaluation, and professional editing. The new medium offers new opportunities for what kinds of texts may be published, and how they may be distributed, but the procedures for deciding what will be published remain

essentially the same. Presses will find, however, that new skills will be needed among their evaluators and editors as well-tagged and electronic-only texts become available and in demand.

One serious danger for the scholarly press posed by the new medium is the increasing tendency to rush materials into print. What used to take months to typeset, review, correct, and finally print and distribute can now go from final edit to world-wide distribution in a matter of minutes. As a result, publishers' (and marketers') time horizons have shortened dramatically, putting pressure on the evaluating and editing functions to follow suit. Although word processors have reduced the time needed to perform many editorial functions, the process of careful reading, restructuring, advising, redrafting, and copy editing has not changed at all. In fact, the loss of the time that used to lapse between the many stages of producing a book have eliminated many opportunities for correcting mistakes along the way, increasing the need for accuracy at each step.

The growing desire among Web readers for more gate-keeping and screening of the information available is one influence that counteracts the forces working to reduce the quality of evaluation in the publishing process. Evidence of this desire can be found on the home pages of the new electronic-only journals, which often announce prominently the fact that the articles contained undergo peer review. During the age of print-only journals, the fact of peer review was often taken for granted; most journals never bothered to announce it. Readers had to consult reference works, such as the Modern Language Association's *Guide to Periodicals*, to determine which print journals conducted peer review or blind submission. That the e-journals feel the need to trumpet this feature suggests the growing desire of the reading public for more screening to help them judge the quality of the e-texts they read.

Electronic-Only Texts

Even as traditional texts are digitized and tagged for the electronic medium, new possibilities are arising for publishing e-texts that either cannot, or cannot reasonably, be duplicated in the print medium. Simplest among this type are massive databases or collections of letters or other records that, because of sheer size, would not be feasible to publish. Virtually free, world-wide distribution, combined with powerful search engines, multiply the value of such collections immeasurably.

At the opposite extreme is the dawning world of virtual reality (VR), which holds out the prospect of creating publishable "texts" no part of which can be rendered in the two-dimensional format of the printed page. Interactive stories, multilayered texts, graphic displays the reader may "walk" through and interact with, and many more as yet unimagined possibilities will all be common in years to come. Publishing houses will be competing with entertainment and software companies for this emerging VR market.

In between the two extremes are e-texts that combine traditional text with audio and video components. Although the CD-ROM market has been slow to develop, and is widely questioned at the present time, a number of presses have begun to publish in this medium. For example, Rutgers University Press produced *The Rebecca Project*, which the magazine *Lingua*

Franca describes as an “award-winning” CD-ROM “which scrutinizes Hitchcock's film using everything from archival screen tests to Lacanian critique, has sold just under 250 copies” (Zalewski 10). This small number of sales is indicative of the difficulties surrounding the underwriting and marketing of the new medium. While the nearly free Internet surges in popularity, the revenue-generating projects needed to sustain scholarly projects is proving harder to develop. Despite the problems, CD-ROM is still widely used for electronic storage by not-for-profit organizations, such as library-based electronic texts centers, and is likely to have a brighter future once the market settles on a common format.

Electronic Vandalism

“Hackers Penetrate Justice Dept. Home Page” announced *The Washington Post* (A22, Sunday, 22 August 1996). Even with professional management of its World Wide Web site, the US Department of Justice fell victim to a new form of vandalism. Lucky for Justice that the vandalism was amateurish, easy to detect, and caught early. For e-publishers, the threat can be even more sinister, given that vandals can also infiltrate an electronic text archive on the Web and alter text with the intent of giving the impression that the result was intended by the publisher. Most Web server arrangements provide backup systems that reinitialize once a week; if the vandals' handiwork goes unnoticed for longer than that, even a careful backup system may not prevent the corruption of a large part of a publisher's e-text program.

E-publishers and Web server providers must be kept aware of the possibilities of e-vandalism and establish procedures to counteract the threat. Besides developing new and better ways to prevent or thwart vandalism, Web publishers must review their materials regularly to ensure that on-line texts are accurate and uncorrupted. They must be ready to pull the material off the Web at any time. CD-ROM or tape-drive backups of a publisher's full archive must be kept ready to replace corrupt texts.

Electronic Texts in the Curriculum

Despite the problems and challenges of the new electronic medium, e-texts are certainly here to stay. Besides promoting profound changes in the way we conduct research and publish the results, the electronic information revolution will also generate changes in both the actual and virtual classroom. Electronic submission of homework and e-mail critique of papers are already standard procedures at many colleges and universities. Many students now rely on CD-ROM or Web-based bibliographies and other research tools—so much so that some are surprised to discover print versions of their various disciplines' standard reference works.

Instructors everywhere are experimenting with the use of e-texts in the classroom. Even in traditional classes in which the students meet with their professors in a physical room to discuss topics seemingly far removed from the computer world, the electronic revolution is being felt. For instance, Professor Stephen Railton at the University of Virginia has developed a CD-ROM and World Wide Web project entitled *Mark Twain in His Times: An Electronic Archive*, in which Railton and the staff of the Electronic Text Center teach students to photograph, scan, transcribe, and electronically “tag” texts by and about Twain and add them to the Web site.

Students thus learn about the new medium while also learning about Twain's works and times. Other similar projects are cropping up throughout the world, as educators explore the pedagogical possibilities of the new electronic resource.

The scholarly press has undergone dramatic changes during the two or three decades of the information revolution. Gone are the typesetters and manual layout designers; indexers and proofreaders are endangered species. Despite these changes, the scholarly press is retooling for the new environment, and is, in certain respects, on the cutting edge of the electronic revolution. In the midst of all the challenge and excitement, though, the scholarly presses and the institutions that support and nurture them must take care to ensure that they remain centers of excellence that help the reading public screen and judge the quality of published material—whether in traditional print format or in the newer electronic forms. Ways will be found to collect revenue from electronic products, and computer languages and electronic formats will eventually settle down into a series of predictable standards. Meanwhile, the scholarly presses must seek to maintain their standards regardless of the forms their products take.

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Active Visual Learning in Mathematics with Technology: More Students Learning Faster and Better

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Technology has aided greatly the teaching of mathematics in recent years. Empowered with computers, undergraduate math courses now include more applications, experimentation, and visualization. In this article we discuss the current trends and future opportunities of technology in collegiate math education.

In the mid-eighties the National Science Foundation launched a major initiative to improve the quality of calculus instruction at the national level. During the years 1988-1991 alone the NSF awarded nearly seven million dollars to support innovative calculus projects. As a result, many math departments around the nation now teach calculus courses which include more applications, more experimentation, and more visualization. Calculus courses are using technology increasingly to handle the complicated computations and "real-world" data arising from applications. Software packages such as *Mathematica* now provide students with the mental pictures necessary to understand the mathematics.

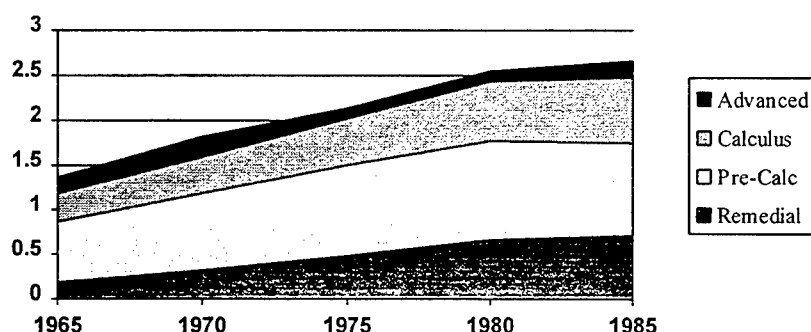
These changes in undergraduate math education are not unique to calculus. Similar changes are currently occurring in pre-calculus, differential equations, and linear algebra; the NSF fully expects to reform the entire undergraduate math curriculum (National Research Council, 1991). Given this state of change, one might wonder what undergraduate math courses will be like in twenty-five years. In particular, what role will technology play in future college math courses? What will happen to symbolic manipulation in upcoming years when college students own calculators which handle most of the computations normally done by hand? What types of computations will be necessary in future math courses? In order to begin to answer these difficult questions one needs to consider the forces driving the change.

What is driving the changes in Math Education?

One of the major forces behind the change is the increasing number of students who need knowledge of higher mathematics. Indeed, the demand for mathematical literacy has grown by leaps and bounds over the last couple of decades with the increasing need for quantitative skills in sociology, biology, behavioral sciences, business, finance, politics, and defense. Mathematics is no longer just a tool for the physical sciences. Mathematics is a language for all disciplines.

The following table illustrates the increase in total undergraduate enrollment in mathematical sciences departments at US colleges and universities (*Moving Beyond*).

Total Undergraduate Enrollment (in millions)
in U.S. Mathematical Sciences Departments



As the table indicates, demand for mathematics has increased at the remedial, pre-calculus, and calculus levels over the past few decades. Meanwhile, the number of students enrolled in advanced math courses has remained nearly constant. This trend seems to indicate the math department's role is already more heavily weighed toward servicing other disciplines. Mathematics departments of the future will face the challenge of teaching larger numbers of students with even more diverse backgrounds.

Another force behind the change in mathematics instruction is the increasing need for skills for the current information age as electronics becomes central to many aspects of everyday life. As cited by John Kenelly in his discussion of the past, present, and future uses of technology,

Today's automobiles have more computing devices than the Apollo capsule. Business is a vast network of word processors and spreadsheets. Engineering and Industry are a maze of workstations and automated controls. Our students will have vastly different careers than we... (24)

Today's colleges and universities must meet the changing needs of society by preparing a significantly larger portion of the population for their information-intensive professional lives. Mathematics departments, in particular, must prepare not only the scientists and engineers who make up the intellectual base of the information age, but also the growing proportion of the population who will need to use the concepts of calculus. Mathematics instruction will have to be in a state of continuous change if it is to be successful in preparing students for the future.

Fortunately, math departments have technology to help them in their endeavor. Empowered with computers, many undergraduate math courses now include more visualization, more experimentation, and more "real-world" applications.

Benefits of technology in teaching mathematics

Visualization. One of the greatest opportunities for technology to improve the teaching of mathematics is in the arena of visualization. Graphing capabilities of sophisticated math software packages such as *Mathematica* and *Maple* now make it possible for students to develop

the mental pictures behind mathematical concepts much faster than in the past. Whereas a decade ago students struggled graphing simple rational functions, such functions (as well as much more complicated ones) can now be graphed with a few keystrokes. With the use of technology, pre-calculus students are exploring the local and global behaviors of functions by "zooming" in and out of their graphs. In calculus they are watching the convergence patterns for series of functions. Students in differential equations are graphing flows in various velocity vector fields. At all levels of the undergraduate mathematics curriculum, technology is allowing students to visualize the mathematics. We hoped this visualization will result in better student understanding and retention. To quote Deborah Hughes Hallett, author of a leading calculus reform text,

Students operating with few mental pictures are not really learning mathematics. Their calculus consists of a vast series of algorithms and a complicated cataloging system which tells them what procedure to use and when. (121)

Student experimentation and discovery

Undergraduate math instruction also benefits from the experimental opportunities offered by technology. With the advent of powerful microcomputers and sophisticated graphics, it is now possible to construct computer laboratories which allow students to "discover" the results of complex mathematical processes for themselves. By controlling parameters and executing code in pre-prepared interactive electronic lessons, more students are learning mathematics through experimentation. No longer a passive lecture hall, the mathematics classroom is transforming into an active laboratory for thought.

Applications and "real-world" data

In years past, most homework problems and examples found in undergraduate math courses were artificial. Given the computational power available, it was necessary to design problems which led to doable calculations. As a result messy "real world" data were rarely used. Rather, problems were rigged, and students came to believe an answer other than zero, one, or a multiple of pi had to be incorrect. In modern math courses the story changes. Course materials such as *Calculus & Mathematica* (Davis et al), *Calculus: Modeling and Applications* (Smith and Moore), and *Exploring Differential Equations via Graphics and Data* (Lomen and Lovelock) are making significant use of the computer to handle the complicated computations arising from "real-world" applications and real data. In the computer-based *Calculus & Mathematica* materials, for example, students use *Mathematica* to analyze real population data and model the growth of the United States. They also work with predator-prey models, predict clean-up rates of oil spills, and approximate paths of heat-seeking missiles. With the aid of computers, more and more students are discovering mathematics as a necessary tool for many disciplines.

Technology: A word or two of warning

Given the benefits of technology and its impact on the educational process, it is still necessary to keep in mind that technology can hinder student learning if it is not implemented correctly. In particular, one of the most commonly made mistakes regarding technology in

mathematics education is the use of technology for the sake of technology. Technology should always be implemented into a course with a purpose. Repeating what can be done by hand on the computer is neither enlightening nor interesting. As stated in *Everybody Counts*,

Technology should not be used because it is seductive, but because it can enhance mathematical learning by extending each student's mathematical power. Calculators and computers are not substitutes for hard work or precise thinking, but challenging tools to be used for productive ends. (121)

It is also important to keep in mind that the pictures appearing on the computer screen are worthless if students don't "see" what they mean. Dazzling a class with pretty pictures is not the purpose of educational technology. Computer graphics need to be well-chosen to illustrate the mathematical concept at hand. More importantly, students need to be actively involved in their learning. They need to be actively engaged with the ideas illustrated on the screen. Just because a student sees an illustrative graphic or animation on the computer screen does not mean the student understands what it means or why it is important.

Visions of the future in undergraduate math education

Given the current rate of change and the forces behind the changes, what can we say about the next twenty or thirty years? What will happen to collegiate mathematics in the future? Although these are difficult questions to answer, we would probably be safe guessing that undergraduate math education will continue its route towards a more active and visual experience for the student. With the aid of technology, students will be more apt to experiment and discover the underlying concepts of calculus or linear algebra or differential equations. Other probable (and related) changes include:

Laboratory settings will replace the traditional lecture-based learning of the past.

Classrooms of the future will be more versatile, enabling instructors to take advantage of the resources available. It won't be long before students will be able to plug in their own computers (calculators?) in class, making the classroom an instant computer lab. Students will also have access to the internet in class, allowing them to take advantage of valuable resources from all over the world.

Developments in technology will significantly change the role of symbolic manipulations in undergraduate mathematics. Currently there are already calculators which can handle much of the computation found on standard calculus exams. In the near future these calculators will be cheap enough for all college students to own them. With this development it will be necessary for every math department to reconsider the symbolic manipulations found in each of their courses. Which manipulations remain relevant in calculus, linear algebra, and differential equations? Should students in algebra be expected to memorize the quadratic formula when their calculator can hold this equation for them? Should calculus students learn how to graph functions when their calculators can do it faster and more accurately? Is it necessary to learn the various techniques of integration? How competent should students be at computing derivatives using the Chain Rule? All of these questions need to be considered, however, math departments are only now starting to address them.

Math instruction of the future will be more interdisciplinary. With enrollments increasing in entry-level courses, math departments will become more service-oriented, and math instruction will reflect this. In the years to come, we will see math taught in conjunction with other departments. Students will continue to be assigned projects which incorporate concepts from other disciplines. Software which makes it possible for students to explore, compute, organize and report all in one environment will enable students to handle valuable interdisciplinary problems more easily.

Distance learning in mathematics will become more prevalent as the information highway becomes more sophisticated. Students living in remote areas will take calculus and other math courses from universities by way of the internet.

Conclusion

Developments in technology will remain a driving force for change in math instruction. As it becomes increasingly difficult to draw the line between a calculator and a personal computer, the visual, experimental, and computational capabilities of technology will become increasingly important in the teaching of mathematics. Computers will influence the mathematics classroom by making the learning of mathematics a more active "hands-on" experience for the student.

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WebEd: The Deep Play of Hypertext Learning

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In this paper, Professor Hochman examines how web pages create new learning spaces in composition education.

Nowadays, it's quite fashionable to project the end of books or to promote the possibilities of reading on line. Although I cherish my books and believe buying first edition books will be even more fun than holding onto baseball cards was in the fifties, and although I love computers and have designed and implemented a computerized classroom, I'm quite happy to think that 21st century reading will involve reading both hard texts and hypertext. However, I also suspect that we have not seriously or fully considered the possibilities of hypertext, and it is the purpose of this article to begin doing so.

What is hypertext? The term was coined by Theodore H. Nelson in the 1960s, who said that hypertext means "*nonsequential writing*—text that branches and allows choices to the reader, best read at an interactive screen. As popularly conceived, this is a series of text chunks connected by links which offer the reader different pathways" (0/2). In his 1992 book, *Hypertext*, George Landow furthered Nelson's thinking by explaining that hypertext is "text composed of blocks of words (or images) linked electronically by multiple paths, chains, or trails in an open ended, perpetually unfinished textuality described by the terms *link*, *node*, *network*, *web*, and *path*" (3). Reading hypertext means that one travels through a text in more ways than simply reading pages and turning them. Hypertext is intended to echo the way we think—don't our minds often follow a series of associations shaped by ideas and developing into other ideas?

The World Wide Web, our grand hypertext, increasingly enables learning transactions. Readers on the Web are offered tools that allow them to find a number of alternate paths through their screen experiences. How a screen appears, and in what order screens appear, no longer reproduces the turning of pages. Hypertext adds new dimensions to the reading transaction. Robert Coover describes this process in his essay, "The End of Books":

With hypertext we focus, both as writers and as readers, on structure as much as on prose, for we are made aware suddenly of the shapes of narratives that are often hidden in print stories. The most radical new element that comes to the fore in hypertext is the system of multidirectional and often labyrinthine linkages we are invited or obliged to create. Indeed the creative imagination often becomes more preoccupied with linkage, routing and mapping than with statement or style, or with what we would call character or plot (two traditional narrative elements that are decidedly in jeopardy). We are always astonished to discover how much of the reading and writing experience occurs in the interstices and trajectories *between* text fragments. This is to say, the text fragments are like stepping stones, there for our safety, but the real current of the narrative runs between them. (24)

Computers are reading tools that increasingly encourage readers to find alternate paths in which more and more of the links occur in the reader. Computer reading not only enables readers to insert their own writing, it dethrones authorial authority and linearity as texts' ruling

structures by inserting a more democratic mix of ongoing, alternative structures. In this regard, modern readers of hypertext will do pretty much what Reader-Response critics, Deconstructionists and Post-Modern thinkers have theorized; 21st-century readers will rewrite texts with their electronic eyes.

In spatial terms, the reading transaction occurs on a modern network of multilane highways instead of on narrow, two-way streets. As Jay David Bolter might add, "the key is the electronic link, which allows us to build and explore trees or networks, to turn trees into hypertext" (Bolter, 1991). The fact that there are many paths through a computer text is one of the most explosive changes in reading. The "privileged" path is now privileged by readerly actions that parallel what writers do to order their texts.

Certainly, with such an increase in reading possibilities virtually exploding on screen, educators must decide either to let the Web become a place of commerce and entertainment, or to stake out territory on the Web for valuable learning resources. It is difficult to compete with the flash of commercial sites and the dazzle of Madonna or whoever is hot at the moment, but it might be possible to "play" with those attractions and at the same time exist educationally on the web.

In order to think about how educators may avoid the "TVing" of the Web, consider first Clifford Geertz's use of Jeremy Bentham's concept of "deep play." In his classic essay, "Deep Play: Notes on the Balinese Cockfight," Geertz describes "deep play" as play risking stakes so great that it is, from a practical standpoint, irrational for people to engage in. Nonetheless, Geertz goes on to show how a particular form of deep play (cockfighting) was integrated into the very fabric of Balinese culture. Indeed, reading Geertz's essay can make one notice varieties of deep play in all cultures and understand deep play as a key means of increasing meaning in our lives.

Imagining that education can exist on the World Wide Web is a bit like building a school right next to a multiplex theater and hoping students won't cut class to go to the movies. However, because hypertext so powerfully echoes thinking modes, and because the Web makes hypertexts so publishable and accessible, it would be silly for educators to ignore the learning resources of the Web. We need to accept the "deep play" challenge of creating Web pages that educate because making meaning is the essence of both "deep play" and education.

One of the ironies of reading Web pages is that the more links in the page, the more likely the reader will value the page, though not necessarily by staying in it. Not only is there "deep play" in risking our students' eyes on entertainment screens, but there is an even more basic form of "deep play" in that any text with links is likely to make the reader leave it rather quickly. The risk of leaving a Web page, however, is moderated by the use of bookmarking—creating an ongoing computer file of interesting Web addresses. If a Web page is up on the screen, one can easily add a bookmark to one's own hypertext record of web experience and then easily return to the Web page for future experience. This changed reading dynamic means that educators must supply their sites with plenty of links, that the sites must be worth bookmarking,

and that educators must begin to understand that hypertext reading is something very different from more traditional reading acts.

There are many exciting ways educators can accept the deep play challenge of offering interactive information and ideas . At the University of Southern Colorado, Gretchin Lair and I have created three pages that are designed to help our writing students. Though we are only beginning to explore the learning possibilities with these pages, initial feedback has been positive.

First, we created a department home page (<http://meteor.uscolo.edu/english>) so that our students could learn about their teachers. We created links to our professors' syllabi, academic interests, past schools, favorite authors, personal interests, and personal home pages, as well as offering such standard communication information as office hours, telephone numbers, and an e-mailer. We offer more information about professors and more "play" with who they are than students can obtain anywhere else on or off campus, except through face to face experience. Most department members feel that students who access their page have a better sense of their teachers. None of us believes that our department Web page is a substitute personal contact between professors and students, but we do know that it increases students' opportunities to learn about us and our interests.

Second, we created a "MacLab" page (<http://meteor.uscolo.edu/macslab>) to help students in our computerized writing lab access both the lab's resources and the Web's writing resources. This page offers information about the lab, monitor hours, and Macintosh resources, as well as collecting a good array of writing resources such as an on-line dictionary, thesaurus, style guide, etc. It is actually a good "jumping off" spot for Web surfers, because it offers links to the Web's most common search engines. The page is designed to help students in freshman year Composition classes understand their "MacLab," experience on-line writing resources beyond those of a word processor, and begin to surf the net for research purposes.

Third, we created a Writing Center page (<http://meteor.uscolo.edu/writingcenter>) to make it possible for our students to send their writing to a tutor and receive feedback electronically. Though cyber-tutoring doesn't replace face-face-tutoring, it can offer a paperless way to quickly access writing help. This page includes links to a huge variety of writing resources and exercises that are especially useful for developmental writers.

Politicians, generals and administrators take heed—I am not suggesting that Web sites replace classrooms or teachers. Nor do I think that computer screens will replace books. However, I am suggesting that educational Web sites with effective links to learning resources do add to the variety of ways we teachers may interact with our students. Although the pages I've described are small educational steps, and although we clearly risk "TVing" our students, I believe that the hypertexts I've mentioned and those many more that already exist and will exist on the World Wide Web (there's a new Web site created every 4 seconds) can succeed in giving students a more playful and deeper educational environment. The ways of experiencing education are changing just as the nature of reading is changing. Despite the risks entailed in our "deep Web play," if we are going to win the "screen wars," educators must learn how hypertext

changes reading and begin to create Web sites to better interact with our increasingly on-line students...and world.

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Airpower: An Interactive History of Powered Flight

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The History of Airpower is a multimedia CD ROM-based project which allows students to navigate through a significant body of historical data. The program has over 2000 rare photographs, over 80 original articles, and 25 video presentations. Students can add and create new articles with imported and program data and develop multimedia essays. The program was designed to enable the development of critical thinking and communication skills, and is used in both introductory and advanced history courses.

The United States Air Force Academy's Department of History, working in cooperation with the Smithsonian's National Air and Space Museum and the Historical Service of the French Air Force, has launched an unprecedented effort to bring interactive multimedia technology to the study of airpower. While the end result will be a series of modules that focus on aviation in the great wars of the twentieth century, the overall purpose is to study the interaction of people and technology with airpower as the organizing principle. The educational and software designers involved in the project are particularly interested in two things: how best to exploit the multimedia dimensions of a body of knowledge, and how to evaluate the ability of interactive technology to promote learning. Although the primary intent is to serve cadet education at the Air Force Academy, "Airpower" may be effective in other educational and commercial settings.

The Air Force has assembled a powerful team of designers, historians, archivists, and program management specialists to complete the prototype module, which deals with the air war over the Western Front in World War I. Content was given first priority. Noted aviation historian John Morrow of the University of Georgia scripted the 81 "articles" (slide shows and videos) that comprise the bulk of the current data base, while Synapse Technologies of Los Angeles and Ikonix Interactive of San Francisco handled production and program architecture under government contract. The National Air and Space Museum and Historical Service of the French Air Force lent archival, linguistic, and editorial support. In a midstream refinement, the Academy's management team found it useful to send the script writer, archivist, and director into European photo and film archives as a team to cogenerate script and supporting media. The team's expedition streamlined production costs without sacrificing historical accuracy to the "iconographic license" that pervades most documentary material. The result is professionally manicured content with extraordinary consonance between the textual and visual components of the data base.

The next priority in the World War I treatment went to creating an infinitely expandable data base with multiple entry points, search strategies, and tools for manipulating data—with maximum use of off-the-shelf software to minimize custom programming and software maintenance. After several iterations, designers settled on DOS FoxPro 2.6 for a database management system with Visual Basic and Video for Windows tie-ins for program architecture and video playback. The database uses a WAIS inverted index search engine with three distinct interfaces for access. The first and default interface is an historically oriented "Theatre of Inquiry" with a map, time line, and subject header that parses the data base in real time. The second is an "applesque" menu-driven database that allows search by title, author, article content, or general index.

The third interface permits bipolar relational concept browsing. For example, the user could search the data base using the concepts of morality and chivalry as they relate to the article on the "Ace as Hero" and find related material in articles on George Guynemer, Manfred von Richthofen, or training of French, English, German, and American pilots for the war. In all cases, searches are machine-generated based on the number of times selected key words appear in an article as "hits." Abstracts are, however, "glued" to article text and hits in the abstract count double. This feature lets system administrators insert and weight core or meta concepts that do not appear in article text but are nonetheless present. On the other hand, machine-generated searches avoid the highly subjective and labor-intensive process of manually assigning concepts to each article and parametrically "weighting" them on a relative scale.

"Airpower's" relational database is equipped with a full array of informational and manipulative tools. Articles are supported by a glossary that explains technical aviation terms, while a click on the "place" button brings up a map relevant to the subject in view. Articles also come furnished with backup archival material—letters, diaries, operational reports, and some 2500 photos accessible through the "archive" tool. A bibliography with 1700 entries includes primary and secondary sources on World War I aerial warfare, and the "source" tool embodies a natural outgrowth of a project rooted in history and multimedia. Clicking "source" on a text file produces a standard bibliographic citation; all media, on the other hand, are sourced by caption and archival location. Additionally, photos and film travel with "media notes" that reflect the insights of project archivists. Users can record their own insights via a "notepad" function and "import" these observations into the shared data base.

Import and assembly capability is one of many features that distinguishes Airpower. The data base is designed for expansion through a combination of internal cutting and pasting, and importing external digitized material. All media and text can be marked and stored in a "scrapbook" for future assembly into slideshows or videos. As a proof of concept, program tutorials will be built using the "assemble" tool and then imported into the information section of the main toolbar. Project designers recognized creation as the highest form of understanding and devoted considerable resources to developing flexible assembly and import mechanisms to make Airpower a living database. Life, of course, brings its own set of problems. At issue is the administrative mechanism for distinguishing private from shared databases, particularly in the context of network computing environments.

Less problematic but equally stunning in potential is "Airpower's" bilingual capability. Given the ascendancy of France in the first air war, designers chose French as the companion language to English. All articles are bilingual in text and voice-over, while program navigation can be engaged in either language. The Historical Service of the French Air Force provided all translations, and voice-overs feature native speakers. Program architecture was designed for multiple language capability, and content alone suggests German for future production.

Short of rigorous beta testing, "Airpower" is not intended for widespread distribution. Beta sites include Dr. Tom Reeves' multimedia laboratory at the University of Georgia and the IBM electronic classroom at the Air Force Academy. The latter is particularly helpful because the Academy's Department of History teaches a course on the first air war, and the electronic data base

is an integral part of a syllabus that includes traditional textbooks and lectures as well. Students presently taking the course are not only required to perform research in the Airpower data base, but they must assemble photo essays and multimedia presentations as a part of their graded work.

The Academy setting begs a larger question that haunts multimedia production in general. Will it be CD-ROM, network, or both? Airpower is ROM-based but specifically designed to run on the twenty-station token net in the Air Force Academy's electronic classroom. Beyond that, the Academy is fitted with one of the more robust fiber-optic networks in the country. All tolled, USAFANET comprises 7500 computers, 70 servers, and has a 20 megahertz bandwidth. Network consultants and system designers are wrestling with the problem of porting high-bandwidth video to multiple users, while instructors are toying with the idea of conducting class from office to dorm rooms, and the institution's military leadership frets over the notion of cadets booting up for class in their bathrobes.

After beta testing and final acceptance of contracted work, "Airpower" could be made available to the public through commercial venues. The market could possibly support two versions. The first should appeal to aviation enthusiasts. It will include the rich historical data base and a flight simulation package that permits users to fly and fight in the airplanes and campaigns they've researched. The second version would target the educational market and emphasize the ability to assemble material from within the database and import new material with fresh interpretation.

In any event, "Airpower" users will discover a unique synthesis of media, technology, and scholarship. Seldom do we find such synergy between a topic and the medium of presentation. The vast history of powered flight may indeed present a suitable platform for understanding multimedia as well as the more general relationship between people and technology.

Effective Dimensions of Web-based Learning

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The World Wide Web (WWW) is attracting the attention of institutions and academics around the world as a vehicle for interactive learning. Despite all the attention (and in a few universities and colleges, substantial investments of financial, human, and temporal resources), results are unclear. In fact, little agreement exists concerning the effective dimensions of interactive learning that can or should be implemented via the WWW. This paper presents a model of interactive learning based upon research and theory in instructional technology, cognitive psychology, and related fields.

Introduction

The World Wide Web (WWW) is attracting the attention of institutions and academics around the world as a vehicle for interactive learning. Despite all the attention (and in a few universities and colleges, substantial investments of financial, human, and temporal resources), results are unclear. In fact, little agreement exists concerning the effective dimensions of interactive learning that can or should be implemented via the WWW. This paper presents a model of interactive learning based upon research and theory in instructional technology, cognitive psychology, and related fields.

This tentative model is proposed because analysis of the critical dimensions of interactive learning should precede the development, implementation, and evaluation of Web-based learning. The proposed model includes ten dimensions of interactive learning: 1) pedagogical philosophy, 2) learning theory, 3) goal orientation, 4) task orientation, 5) teacher role, 6) metacognitive support, 7) source of motivation, 8) accommodation of individual differences, 9) cooperative learning, and 10) structural flexibility. This set of ten dimensions is by no means exhaustive, and enhancements to strengthen its utility as a tool for revealing the powers and limitations of Web-based learning are expected and encouraged. Nonetheless, this model addresses a fundamental problem among educators, i.e., the failure to understand that what is really unique about Web-based learning (and any other form of interactive learning system) is not the mix of media features such as text, graphics, sound, animation, and/or video, but the pedagogical dimensions possible with such a system. Web-based learning systems are only vehicles for these dimensions. Although the WWW may be more efficient or less costly than other vehicles, it is the pedagogical dimensions that will determine its ultimate effectiveness and worth (Clark 1994).

Ten Dimensions

Each of the ten dimensions in this model is presented as a two-ended continuum with contrasting values at either end. For example, the dimension of "collaborative learning" has "unsupported" (the system does not support collaboration) at one end and "integral" (collaborative learning is essential to the system) at the other. Of course, there is an inherent oversimplification in a model based upon two-ended dimensions. The world is rarely dichotomous and there is much more complexity involved in learning than any single dimension represents. However, the individual dimensions themselves are not as important as the patterns

or arrays across the ten dimensions that are present in different forms or examples of Web-based learning.

Pedagogical Philosophy: Although most faculty claim to recognize that each person brings a unique set of prior experiences, knowledge, and skills to any given learning opportunity, the ways they implement technologies (e.g., computer-based instruction) are often grounded in fundamentally instructivist or tutorial structures (that assume all learners learn the same way) rather than constructivist or tool approaches (that assume learners have unique learning styles). The “pedagogical philosophy” dimension ranges from a strict instructivist structure to a radical constructivist one. Instructivists stress the importance of objectives that exist apart from the learner. Once objectives are identified, they are sequenced into learning hierarchies, generally representing a progression from lower to higher order learning. Direct instruction is designed to address each of the objectives in the hierarchy employing strategies derived from behavioral psychology. Little emphasis is put on the learner per se who is viewed as a passive recipient of instruction, or as an empty vessel to be filled with learning. Instructivists espouse an objectivist epistemology that defines knowledge as separate from knowing. They believe that reality exists regardless of the existence of sentient beings, humans acquire knowledge about this reality in an objective manner through the senses, learning consists of acquiring truth, and it can be measured precisely with tests. By contrast, constructivists emphasize the primacy of the learner's intentions, experience, and cognitive strategies. According to constructivists, learners construct different cognitive structures based upon their previous knowledge. A major goal of constructivists is assuring that learning environments are as rich and diverse as possible. Instead of an empty vessel, the learner is regarded as an individual replete with pre-existing knowledge, aptitudes, motivations, and other characteristics that are difficult to assess, much less accommodate. Constructivists argue for replacing direct instruction with tasks to be accomplished or problems to be solved that have personal relevance for learners. With regard to epistemology, constructivists believe that knowledge does not exist outside the minds of human beings and that what we know of “reality” is individually and socially constructed based on prior experience. Rather than truth, constructivist learning consists of acquiring viable strategies that meet one's objectives, and at best, learning can be estimated only through observation and dialogue.

Learning Theory: The design of Web-based learning should be informed by educational psychology, especially the learning theories derived from research in this field. Although there are many theories about learning, the two that dominate the design of instructional technologies are behavioral and cognitive psychology. These two psychological theories are often juxtaposed, and the “underlying psychology” dimension in this model has behavioral psychology at one end of the continuum and cognitive psychology at the other. Behavioral psychology continues to underlie the design of most instructional technologies, including Web-based learning. According to behaviorists, the critical factors in learning are not internal states, but observable behavior, and instruction involves shaping desirable behaviors through the arrangement of stimuli, responses, feedback, and reinforcement. A stimulus is provided, often in the form of a short presentation of content. Next, a response is demanded, often via a question. Feedback is given as to the accuracy of the response, and positive reinforcement is given for accurate responses. Inaccurate responses result in a repetition of the original stimulus or a modified (often simpler) version of it,

and the cycle begins again. Cognitive psychologists, by contrast, place more emphasis on internal mental states than on behavior. A cognitive taxonomy of learning states includes simple propositions, schema, rules, general rules, skills, general skills, automatic skills, and mental models (Kyllonen & Shute, 1989). Cognitivists claim that a variety of learning strategies, including memorization, direct instruction, deduction, scaffolding, practice, and induction, are required in learning environments depending upon the type of knowledge to be constructed by learners.

Goal Orientation: The goals of a particular course of study can range from sharply focused ones (e.g., learning to follow strict protocols for handling fires in flight) to general ones (e.g., developing the ability to recognize and solve ill-defined problems). A “goal orientation” dimension, related to the degree of focus of your goals, has sharply-focused at one end of the continuum and generally-focused on the other. Cole (1992) maintains that some knowledge “has undergone extensive social negotiation of meaning and which might most efficiently and effectively be presented more directly to the learner” (29). In such case, direct instruction, perhaps in the form of a tutorial, may suffice for learning. Other knowledge is so tenuous, creative, or of a higher level (e.g., mental models of engineering or intellectual curiosity) that direct instruction is unlikely to be effective. In the latter cases, Web-based learning environments should promote inductive learning, reflection, and the construction of artifacts or models to be effective.

Task Orientation: A basic tenet of cognitive learning theory is that the context of learning is important to learners (Brown, Collins, & Duguid, 1989). Most courses in higher education engage students in tasks that are largely academic (e.g., writing a term paper) as opposed to authentic tasks (e.g., building a model of a power station on Mars). The “task orientation” dimension has academic tasks at one end of the continuum and authentic tasks at the other. Consider a typical undergraduate physics course. An academic assignment might require students to conduct abstract experiments using frictionless balls and ramps. By contrast, an authentic assignment might engage learners in solving problems that NASA confronts in the physics of building a space station. A major concern in education is the degree to which classroom learning transfers to “real life.” Cognitive learning theory indicates that the way in which knowledge and skills are initially learned plays a major role in the degree to which these abilities can be used in other contexts. If knowledge and skills are learned in a context of use, they will be used in that and similar contexts. With academic tasks, it is largely left up to the student to generate connections between conditions (e.g. a problem) and actions (e.g. the use of knowledge as a tool to solve the problem). There is ample evidence that students who are quite adept at “regurgitating” memorized information rarely retrieve that same information when confronted with novel conditions that warrant its application. Authentic tasks can present a challenging task or problem that will serve as the focus for a learner's efforts to construct new knowledge. Web-based learning environments can be designed to guide learners with both academic and authentic tasks.

Teacher Role: Web-based learning environments can be designed to support different roles for teachers. Some sites are designed to support the traditional didactic role of the instructor as “the teacher,” i.e., they present the teacher's syllabus to the students, distribute the

teacher's readings, or otherwise support teacher-centered instruction. Other sites are designed to place teachers in the role of a "facilitator." The "teacher role" continuum ranges from didactic to facilitative. A quarter century ago, Carroll (1968) told us that "By far the largest amount of teaching activity in educational settings involves telling things to students..." (4). More recent analyses of teaching in universities and colleges indicate that little has changed since then. There is much talk about a shift in the teacher's role from a didactic one to that of a facilitator, but most instructional technology research is focused on how the computer can be used to present information and judge learner input (neither of which computers do well) while asking learners to memorize information and later recall it on tests (which computers do with far greater speed and accuracy than humans). We would do better to assign cognitive responsibility to the part of the learning system that does it best. The learner should be responsible for recognizing and judging patterns of information, organizing it, constructing alternative perspectives, and representing it in meaningful ways, while the computer should perform calculations, store information, and retrieve it upon the learner's command. The WWW is a powerful vehicle for the latter approach in which the teacher becomes a guide, mentor, coach, and collaborator in the learner's knowledge construction process.

Metacognitive Support: Metacognition refers to a learner's awareness of objectives, ability to plan and evaluate learning strategies, and capacity to monitor progress and adjust learning behaviors to accommodate needs (Flavell 1979). In short, metacognitive skills are the skills one has in learning to learn. The metacognitive support dimension is unsupported at one end of the continuum and integrated at the other. A WWW site can be designed to challenge a learner to solve a technical problem such as troubleshooting an electrical short in a circuit board or a social problem such as a local environmental issue. A learner using such a site with integrated metacognitive support would be able to request the system to recapitulate his/her troubleshooting or problem-solving strategies at any point in the learning process. Research studies reported in Lajoie and Derry (1993) indicate that much progress remains to be made before most educational technologies include sophisticated metacognitive support. How metacognitive support might be provided on the WWW is an area in need of much research.

Source of Motivation: Motivation is a critical factor in teaching and learning. Intrinsic motivation has been held forth as the "Holy Grail" to which all educational technologies should aspire. The source of motivation ranges from extrinsic (i.e., outside the learning environment) to intrinsic (i.e., integral to the learning environment). Intrinsically motivating learning is very elusive regardless of the delivery system, but virtually every new technology to come along promises to be more motivating than any that have come before. For example, the Web is said to motivate learners, simply because of the integration of music, voice, still pictures, text, animation, motion video, and a user-friendly interface on a computer screen. Actually, studies indicate that learners may tire of these media elements and that motivational aspects must be consciously designed into the WWW just as rigorously as any other pedagogical dimensions (Reeves 1993). The motivation to pursue learning opportunities is more often driven by economic and social factors than those of personal development. Despite the power of the WWW, extrinsic motivation remains a critical factor in most education contexts.

Accommodation of Individual Differences: The power of technology to accommodate individual differences such as intelligence, locus of control, learning styles, anxiety, and attitudes (just to name a few) is a major interest of increasing numbers of faculty. The "Accommodation of Individual Differences" dimension ranges from unsupported to multifaceted. Unfortunately, the research foundation for multifaceted individualization is still weak (Jonassen & Grabowski 1993). It may be beyond the capabilities and resources of most teachers to design Web-based learning environments that include diverse resources for different types of learners. However, an approach whereby learners are enabled to create alternative WWW resources for themselves or their peers can be both feasible and effective (Jonassen & Reeves 1996).

Cooperative Learning Strategies: Web sites can be designed to thwart or promote cooperative or collaborative learning. Some sites require cooperative learning whereas others make no provision for its support. The "collaborative learning" dimension ranges from a complete lack of support for collaboration to the inclusion of collaborative learning as an integral feature. Cooperative learning involves instructional methods in which learners work together in pairs or small groups to accomplish shared goals. When sites are structured to allow cooperative learning, learners can benefit both instructionally and socially. Some conceptions of Web-based learning entail a solitary learner surfing the Web, but many faculty recognize that two or more students working together via an interactive site can accomplish more than a "lonely learner."

Structural Flexibility: The rapid growth of the Internet and the high bandwidth capabilities of the WWW mean that interactive learning can be designed for delivery anytime, anywhere to anyone with a personal computer and a modem. The "accessibility" dimension is a continuum with fixed accessibility with respect to place and time on one end and open accessibility on the other. However, the speed at which learners can access learning opportunities outside of a campus depends on many factors, and distance learning students may come to believe that WWW means the "World Wide Wait." Many educators are experimenting with the delivery of formal and informal learning opportunities via the WWW, but structural problems and bandwidth limitations still hinder these efforts. As the Information Age becomes more and more technically feasible, the relevance of this dimension in the model will be diminished in the future.

Applying the Model

As a model of the critical pedagogical variables incorporated within WWW sites designed to support learning, this model has applications in research, design, implementation, and evaluation. Figure 1 illustrates one possible use of the model in terms of differentiating between different forms of Web-based learning. The sites described below are hypothetical. Web A in Figure 1 was designed by faculty to provide support for undergraduate chemistry courses. Its instructional design includes both direct tutoring and drill-and-practice using principles of behavioral psychology to stimulate and reinforce learning of formulas and other discrete knowledge. The teacher's role is primarily facilitative because the computer has assumed the major share of direct teaching. It provides little accommodation for individual differences or metacognitive support. No collaboration is supported, and its heavy dependence on digital video means that most students can only use it on campus. Web site B is a constructivist

program about HIV/AIDS for students enrolled in medical education and allied health programs. An elaborate scenario is the focus of learner activity. There are no right answers to solving the problems presented in the scenario. Faculty are collaborators in the intrinsically motivating quest to solve the problems of real and simulated HIV/AIDS patients. Site B does make special allowances for individual differences and provides for high levels of learner control and collaborative learning. Finally, the designers of this site have also included numerous digital video and sound files, and therefore it is not easily accessible from remote sites via modems.

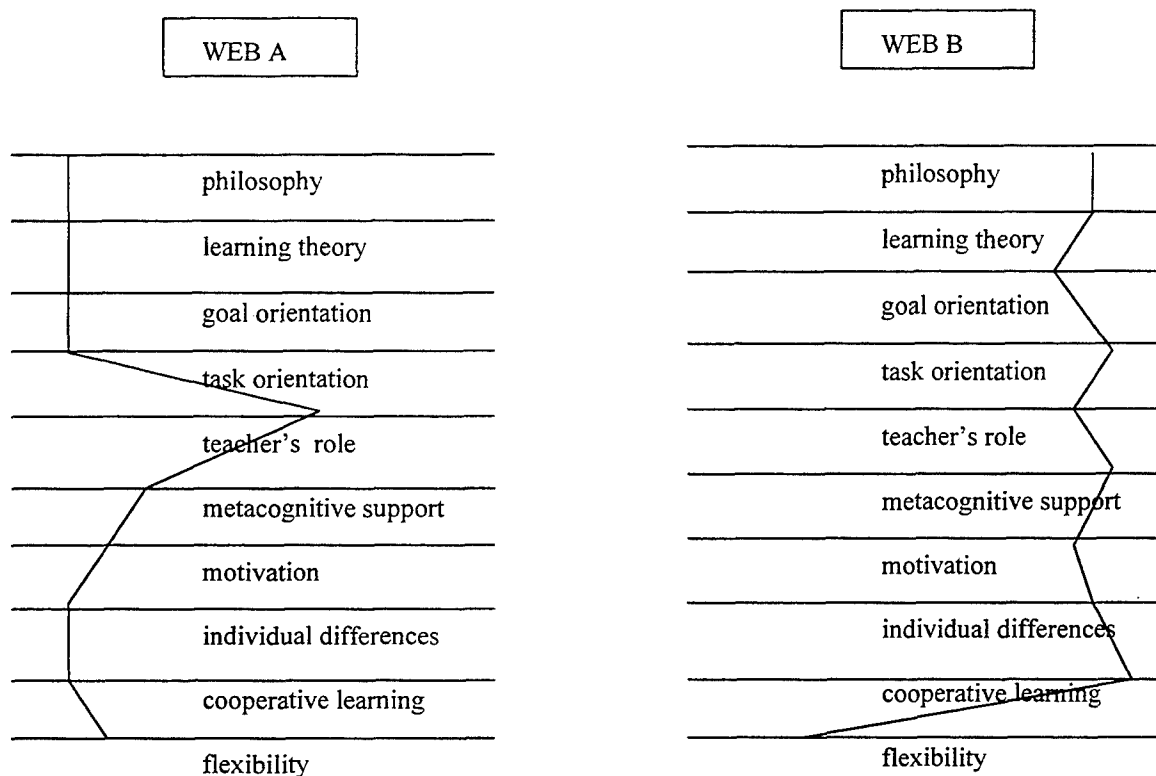


Figure 1. Hypothetical application of effective dimensions model.

Conclusion

Predictions that the WWW will revolutionize higher education and improve its effectiveness abound. To achieve this promise, we must understand the basic dimensions that Web-based learning can (and cannot) accommodate. The model in this paper is neither comprehensive nor complete, but it is a starting point for others to critique, modify, and improve.

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Media Literacy and The Rebecca Project: Teaching Cinema with CD-ROM

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Despite, or perhaps because of, the sheer pervasiveness of visual imagery in postmodern culture, students are only dimly aware of the degree to which such imagery is artifactual, constructed according to the image-makers' intentions. In effect, students are unconscious consumers of visual imagery. We can exploit technological innovations to teach students how images are made and purveyed in order to better educate them in mass media literacy. *The Rebecca Project* allows for effective interactive instruction of cinema technique, image composition, and ideological content of classic Hollywood studio film productions.

We are finding ourselves increasingly in a postliterate era, when images, rather than words, have become the predominant means of conveying information and shaping perceptions and understandings. This post-Gutenberg revolution has an infinite number of ramifications for students and teachers of mass communication, not the least of which is political. Richard Dyer, in *The Matter of Images* (1993), speaks to the political nature of how images represent us. "How a group is represented" through images purveyed by the media "presented over again in cultural forms, how an image of a member of a group is taken as representative of that group, how that group is represented in the sense of spoken for and on behalf of (whether they represent, speak for themselves or not)" all form the basis of the contemporary body politic (1). As Dyer goes on to elaborate, the production and consumption of images are implicated in how members of groups see themselves and others like themselves as members of a state, along with their right to the rights a society claims to ensure its citizens. "Equally, representation, representativeness, representing have to do with how others see members of a group and their place and rights, others who have the power to affect that place and those rights. How we are seen determines in part how we are treated; how we treat others is based on how we see them; such seeing comes from representation" (1). In short, representations, especially those conveyed by images, have real consequences for real people. If we do not have a conscious understanding of how visual images attempt to shape, if not actually manipulate, our political and social order we are, in some sense, illiterate.

But it goes beyond the ways mass visual media determine our politicized sense of ourselves as members of social groups. As John Caldwell points out in a 1992 issue of *Jump Cut*, our understanding of the reality of the historical events occurring around us is determined, and even overdetermined, by these visual media. Wars, for example, become more than events; they become media texts, as well as contexts that transform other visual texts in substantive ways (15). These transformations blur the boundaries between history, or "reality," and fiction, so that the end result is image/reality as artifact. We might think of the media images of what were purported to be surgically accurate strikes of Baghdad during the Gulf War, when it was difficult to tell what might have been animated representation or actual filmed documentation. As Caldwell observes, "Increasingly, both television [video] and film today use visual imagery borrowed from each other. From music videos to commercial spots, filmed images of scan lines, video pixels, and videotape shuttle effects," video-mediated and -created images become mixed with cinematic images (15). This blurring of media forms is a development which has, notably, been interrogated in the films of Oliver Stone like *Natural Born Killers*, *JFK*, and *Salvador*. The result: the distinctions between the medium and the message have gradually been blurred or

camouflaged, so that the image itself becomes not merely our way of perceiving reality, but rather reality itself.

Visual media literacy challenges this and is based on the conscious understanding that representations are always fabricated presentations, as Richard Dyer notes, using "the codes and conventions of the available cultural forms of presentation" (2). Learning how to read these codes and conventions, as they are graven in moving images through visual mass media in postliterate cultures (TV, film, video, laser disc, et al), is a vital component of functioning as an aware subject in postmodernity and in the Information Age. Dyer persuasively argues: "Without understanding the way images function in terms of, say, narrative genre or spectacle, we don't really understand why they turn out the way they do" (2). The images that pervade and even envelop us in daily life are not haphazardly assembled, or purely "found" objects which are only interpreted according to the desires of the consumer. Rather, as Dyer puts it, "we are all restricted by both the viewing and reading codes to which we have access (by virtue of where we are situated in the world and the social order) and by what representations are there for us to view and read" (2).

Educational technology will go a considerable way to enable us to meet visual mass media on the terms established by the seductive power of images. A preeminent recent example of the kind of technology which can be applied to film criticism is Rutgers University Press's *The Rebecca Project* (1995). The transference of cinematic images to CD-ROM goes at least one step beyond cinema on video or laser disc in our ability to understand how images are artifactually produced according to imagemakers' intentions. The authors of *The Rebecca Project* have, in essence, cut up Alfred Hitchcock's 1940 *Rebecca* into segments for "QuickTime" projection alongside information and criticism illuminating significant passages in the film. CD-ROM technology, in essence, can make a visual artifact like *Rebecca* function in the classroom in hypertext form, a far more flexible and effective means of studying and analyzing a film than laboriously cueing up the film on video or laser disc. The authors of *The Rebecca Project* have skillfully integrated clips from a range of Hitchcock's works to illustrate a rich selection of history and criticism about the production and subsequent reception of the 1940 film. *The Rebecca Project* is the first example of a new recombinant medium which will enable us to better integrate written commentary with the visual image to give students the power to comprehend how images work politically, economically, and psychologically, as they work in tandem with ideology, commerce, and desire. Film, therefore, as a medium now has the capability of being made to act as hypertext, for the benefit of close study and analysis. Moreover, the marriage of visual image and written word (which can make the image yet more meaningful) can signal a further advance in the ways students and teachers of mass media can understand how images "work." It is an interactive medium for learning about how images are assembled by their producers for particular ideological consequences for the body politic. With the click of a mouse, the user of *The Rebecca Project* can almost instantaneously move around the linked "chapters" in the CD-ROM devoted to authorship, spectatorship, film marketing, feminist reception theories, and film narrative.

But Utopia is situated well over the horizon. As of this writing, the transfer of film to CD-ROM is still in the very early, and quite tentative, stages of development. So far, Rutgers

University Press has made a limited commitment to the technology, devising it solely for Macintosh users and doing little to publicize it, hampered by the Press's limited resources. Furthermore, the ability to reproduce images in other than black and white is still to be developed. It is significant that the first example of the technology for the purposes of academic study has originated from a medium-scale university press; it is doubtful, therefore, that the considerable economic costs and practical limitations of film on CD-ROM will be overcome until the major trade publishers or entertainment conglomerates also jump on what has so far been a very small bandwagon. Indeed, a less academic approach using more "popular" and contemporary fare may well be the best way to jump-start the bandwagon, rather than relying on academic uses to drive the technology. Yet *The Rebecca Project* is enormously successful at giving students and teachers of mass visual media the power to understand how images make meaning in cultural and political formations—successful enough that we anxiously await future developments in this educational technology. The development of visual and verbal "literacy" is not purely an academic exercise; as I have suggested, this new technology can better enhance our awareness of ourselves as consumers of the images which pervade and influence our very lives and identities.

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Teaching Science Using the World Wide Web (WWW) Protocol

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The World Wide Web provides a new medium for the delivery of instructional materials. In addition to providing easy access to information, the "hypertext markup language" (HTML) and "hypertext transmission protocol" (HTTP) can actually serve as a lesson authoring environment. HTML documents can deliver multimedia information in an almost platform-independent fashion. Furthermore, a WWW server can be linked to an intelligent database for individualized instruction and analysis of students' performance. This paper discusses the rich pedagogical potential of the WWW technology. Where useful, elements discussed are illustrated with examples from the USAF Academy "Cockpit Physics" course, which may represent an early step in what will become a very significant paradigm shift in education.

Introduction

The World Wide Web has already become the vehicle for rapid dissemination of multimedia educational resources. How will this web technology transform education? Let us briefly consider just three possible areas.

1. *Communication and collaborative learning:* The WWW provides unprecedented opportunities for student-teacher, teacher-teacher, and student-student communication. The teacher who provides web-based instructional materials to students outside of the classroom is able to make the students' homework time more productive. Teachers who are geographically separated can jointly develop instructional materials by using web sites. Particularly exciting is the fact that web sites can provide virtual settings for the kinds of collaborative peer instruction which have proven so effective in classroom environments.

2. *Delivery and use of self-paced, independent study materials:* Such materials include interactive supplemental tutorials and review materials, virtual lab experiments and simulations, pre-class assignments, and independent study web research assignments in which WWW resources augment or substitute for traditional library resources. It is important to note that the interactivity permitted by JavaScript code embedded in HTML documents already provides the ability to offer individualized feedback and custom-tailored pathways through the resources. Scripting capabilities will only increase, so the potential of such materials for educational purposes is enormous.

3. *Implementation of fully developed web-based lessons:* The World Wide Web environment can support stand-alone instructional materials as demonstrated by the USAF Academy Cockpit Physics project. Such web-based lessons are not constrained by traditional space and time barriers, presenting a dramatic change from traditional instruction. They can be constructed with built-in interactivity provided by JavaScript and/or by communication with a webserver. Using these materials in a classroom equipped with computers can significantly restructure student and teacher roles, as students take increased responsibility for their own learning, and the teacher assumes the role of the "guide on the side" as opposed to the "sage on the stage."

Although items (1) and (2) are worthy of considerably more elaboration, the remainder of this paper will concentrate on the last area, highlighting features of web-based lessons which provide unique opportunities to improve teaching and learning.

World Wide Web-based Lessons

Key elements of web-based lessons distinguish them from traditional modes of instruction and represent reasons why web-based lessons offer potential for new ways of teaching and learning. Although it is still early in the developmental stages of web-based lessons, institutions like the Air Force Academy have begun investigating these elements as they create and implement web-based courses. Before exploring some of these, let's briefly introduce the Academy's Cockpit Physics course as an example.

Cockpit Physics¹ is a program underway in the Department of Physics at the Air Force Academy. The product of the first stage of the effort is a complete one semester course in introductory physics, consisting of 32 HTML-based lessons in which Air Force relevant themes provide the motivation to learn the underlying physics. The course is highly interactive, with student activities ranging from answering questions to performing hands-on experiments. Students always work in teams, with the web pages of the lessons serving to coordinate the activities. The project explores how to provide effective, individualized, interactive instruction using the technology which will be a part of every student's daily experience.

Web-based lessons represent a unique opportunity for improved teaching and learning for the following reasons

- *relevance and connection to the "real world"*: Web-based lessons can provide links to real world applications of the lesson material. For example, in Cockpit Physics, one of the lessons centered on the Global Positioning System satellites asks students to accept a mission to transfer a satellite from low earth orbit into GPS orbit, using a technique known as the Hohmann transfer. After they accomplish this, they are encouraged to explore a link to a NASA homepage which describes the exact same maneuver and its actual use by NASA in interplanetary space exploration.
- *timely and up-to-date materials*: Because the WWW continues to change and grow, it provides a wealth of new material everyday. Current events can be incorporated into web-based lessons easily, strengthening the connection between the lesson content and the world beyond the classroom. A Cockpit Physics lesson dealing with air resistance as illustrated by a pilot ejecting from an airplane and using a parachute to land safely was able to include a reference to an actual F-16 pilot ejection which had occurred *just the day before the lesson!*

¹ The reader may wish to look at the Cockpit Physics materials on the WWW at http://www.usafa.af.mil/dfp/lessons/cp_home.htm. To see a subset of the materials which includes real-time feedback like that which is provided in the Cockpit Physics classroom, go to http://webphysics.iupui.edu/gpnew/cp_gp0.htm.

- *interactive and student-centered materials:* The web technology allows built-in interactivity via JavaScript embedded in the HTML documents and via submissions to and responses from a webserver. Lessons can be structured so that students can proceed along a path of their choosing, at their own pace. Figure 1 shows an example of a “lesson map” from the Cockpit Physics course; students acquire an overall view of the lesson in one page and then navigate their way through the lesson as *they* choose.



Homework Quiz

Lesson Objectives:

- Be able to show how Kepler's third law (FOR A CIRCULAR ORBIT) can be derived using Newton's second law and the law of gravitation.
- Be able to calculate the period and altitude of geostationary satellites.
- Know and understand how Kepler's three laws of planetary motion are applications of Newton's second law and conservation of angular momentum.
- Be able to apply Newton's second law and conservation of angular momentum to ANALYZE problems involving the orbit of an object about a star or planet.
- Be able to compare different kinds of satellite orbits, and understand why certain types of satellites require certain orbits.

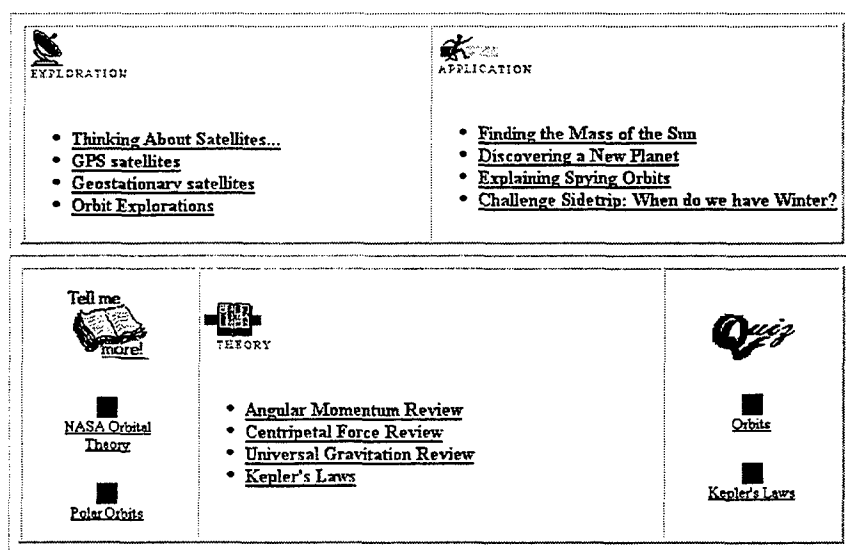


Figure 1: HTML lesson map for a typical Cockpit Physics lesson. The activities are grouped into exploration, theory, and application sections in a modified “Learning Cycle” approach. There are also assessment quiz and supplemental information sections.

- *hidden information available on a need-to-know basis:* HTML documents can include links to layered documents, each of which provides more information about a topic. In Cockpit Physics, layered hints accompany questions the students answer. The strongest students may need no hints, while other students may need multiple layers of hints to answer the questions. Hidden information can also provide greater detail, derivations, and related supplementary information, maintaining a high level of rigor without requiring students to “wade” through all the details in the first pass.
- *multimedia resources which appeal to several senses:* Web-based lessons can readily include text, video, audio, and graphics and can “launch” activities using other applications. Lesson

content can be presented in a variety of formats, thereby supporting different student learning styles. In addition, the commercial “look and feel” of web-based lessons can hold the interest of students from the MTV generation.

- *easy updating/maintenance*: Due to the text-based nature of HTML, web documents can be updated with a simple text editor. New activities can replace old ones with basic “cutting and pasting” techniques. The HTML platform can be viewed as “glue” that can bind together activities which have proven effective in other settings and yet at the same time can offer new activities not possible before. Also, the platform itself can embrace many different pedagogies and learning schemes, so provides a flexible lesson authoring and delivery environment.
- *real-time feedback to instructors and students*: Real-time feedback can enhance classroom effectiveness and dramatically change the way faculty and students spend their time together. What is happening in Cockpit Physics is just a first taste of the richness of what the technology offers.

The significance of the real-time feedback potential inherent in web-based lessons should not be underestimated. While it is clear that Cockpit Physics represents just a first attempt at implementing these features in a real course, benefits are already obvious. Let us consider what the future could hold by logically extending what already exists today in Cockpit Physics.

In the Cockpit Physics classroom, students work in teams of two at 12 student stations. These stations are set up on standard laboratory tables which include hands-on equipment. The classroom intranet network also includes a fileserver and a Macintosh-based webserver. The student stations run web browsers which access files delivered by the file server. Student responses are submitted to the Mac webserver, where they are processed by a logic engine.

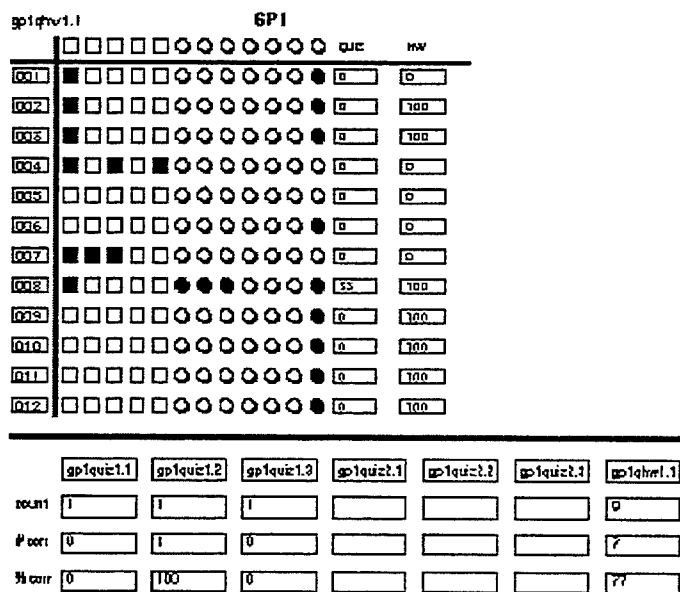


Figure 2: A typical screen displayed by the Mac webserver during a Cockpit Physics lesson.

Figure 2 shows an example of the screen displayed by the Mac webserver in the classroom for each lesson. This system provides immediate feedback to the instructors and records the information in ways that are useful

both in the classroom and for later educational research.

The buttons on the left hand side of Figure 2 represent the 12 student stations in the classroom. Across the top are symbols representing each of the student response items in the particular lesson. The squares represent "text areas" into which students type responses to questions posed in the HTML documents. The circles represent multiple choice quiz items; each circle represents its own quiz question. The names of these text areas and quiz items appear on the instructor's screen when the mouse is dragged over the top row of items. On the right hand side, running percentages on quiz items appear by station.

At the bottom of the screen, information organized by quiz question is displayed for the instructor. For each quiz question in the lesson, the current number of responses, number of correct responses, and percent correct is displayed. This display allows the instructor to quickly assess the class's understanding and trouble-spots as a whole and to take note of questions/concepts which need to be stressed or revisited later in the lesson.

As the students respond to text area input requests and quiz questions, the appropriate boxes and circles turn black. For example, if station #4 submits a response to the third text area in the lesson, this box turns black. This feature helps instructors to gauge the students' progress through the lesson, simply by looking at the placement and quantity of black symbols. To see how students are responding to a particular question, the instructor can click on the item in the top row, and a field containing a chronological list of station responses to this item appears. A quick glance at this field allows the instructor to see how the students are responding to this question; he or she can then engage the class in a discussion based on their answers.

In considering the future of web-based education, it is crucial to note that there is nothing in the design of these materials that prevents doing these same sorts of activities beyond the Cockpit Physics classroom. These station numbers needn't represent computers physically in the same room, in the same building, or even at the same institution. In trial sections of Cockpit Physics during the fall 1996 semester, for example, cadets are doing some web-based exploration activities from their own computers in their rooms, submitting their responses to a server the instructor accesses before the class next meets. The next class then begins with a discussion of the answers the student submitted electronically as part of their homework.

Web-based instructional materials such as the Cockpit Physics lessons can be used by students at different institutions, spread across a wide geographic area. The explosion of the WWW technology leads one to believe that in the future, WWW access will improve for *all* kinds of student populations, so perhaps this is the vehicle to provide increased educational opportunities for all students in the future. The World Wide Web technology also already provides the opportunity to make up seamless interactive instructional sessions comprised of materials from all over the world. For example, students might first take a diagnostic test found at a website in Michigan. Then, based on their demonstrated level of expertise, they might be given instructional materials located in Florida. After completing those lessons, they might proceed to work through a USAF Academy assessment activity. The locations of the materials are transparent to the students, and the ability to access materials from anywhere opens up enormous possibilities. How these capabilities can best be used by students and educators to transform education is a question we in the educational community have only begun to explore.

The Collegial Classroom System: Creating a Student-Focused Educational Environment

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The most essential task of teachers is not necessarily to teach but to have their students learn. Ironically, it is traditional pedagogical strengths rather than weaknesses that create situations in which the distance between students, teachers and learning increases. Additionally, traditional assessment techniques sometimes create adversarial classroom atmospheres. In the Collegial Classroom System, students maximize their learning by assuming a greater portion of the teacher's duties and responsibilities. By allowing students greater control over their own education, and by using several innovative assessment techniques, a classroom climate was created that increased the amount of material learned, while simultaneously increasing students' satisfaction.

"It's not what you teach, it's what they learn." No matter how much knowledge and wisdom teachers possess, no matter how clear their outlines and notes, no matter how much preparation goes into their classes, all that truly matters is what students have gained when they get up to leave. Paradoxically, traditional teacher training focuses more on teacher training than on educating teachers how to facilitate learning. Even the label misdirects efforts; "teachers" should be "learning facilitators." Unfortunately, current approaches to training cause teachers to lose sight of the real goal: improving student learning.

In light of this problem in teacher training, the current focus on technology is problematic. The focus of teachers may become, "what demo do I do," "what video do I show," or "the Web... cool," rather than: "*why* should I do a demo" or "what video would be *appropriate*," or "how might the Web help my students learn?" Overemphasis on attention-grabbing technical theatrics can boomerang decreasing tolerance for "traditional" techniques, which may not be as interesting or enjoyable (Lepper & Chabay 1985). It also has the potential to undermine intrinsic motivation in a subject if technological methods are seen as a reward (Lepper & Greene 1978). In short, we need to examine technology, and every other teaching technique, with a critical eye to ensuring that it does not *increase* the distance between students and their education. Effective techniques, on the other hand, should *decrease* that distance. Teachers need to remember that their job is truly to be learning facilitators.

In fact, rather than technology, we focus on identifying and fixing those areas where the students are furthest removed from the knowledge. Average classes are, by nature, competitive. Most students learn early that the "real" goal is to get good grades, not a good education. Grading itself is also competitive. Teachers often inadvertently create competition among students by grading on a curve. In addition, our evaluation methods become sites of competition between student and teacher, even when tests are not graded on a curve. Teachers test because they do not trust students to learn the material, and the students do their best to guess what the teacher will ask. The game becomes one of intellectual hide and seek; students hide their ignorance and teachers seek to catch them. Distance between students and education in such a classroom is enormous.

The Collegial Classroom System sought to change this classroom atmosphere. Based on earlier theoretical attempts to apply concepts of "total quality" to education, it established a "learning environment," where distance between students and material was diminished and where relations are more collaborative than competitive (Porter 1991). It gave students greater control over their education by giving them the responsibility to teach themselves (and other students) and allowing more choice and freedom. The goals are not grades but increased student knowledge, intellectual curiosity and educational satisfaction. The Collegial Classroom System has three basic components, the *ABC*, which subtly changed three aspects of the classroom: *Accepted/Not Accepted Papers* replaced graded papers; "*Benefit*" Points replaced subjective class participation grading; and *Center on Quizzes* replaced numerous forms of examinations.

Accepted/Not Accepted Short Papers: No Grade Encourages Deeper Thought

Many teachers assign short papers (e.g., essays, journals, critical thinking papers, etc.) in their classes for various reasons: to ensure students understand complex ideas, to have students explore new concepts, to have students apply topics, to have students relate their experiences with the material, etc. Unfortunately, these papers can become another source of confrontation. Students try to figure out what teachers want, then wrap it and deliver it in an acceptable package. Success is, of course, grade-based, which means that students write to produce "A" papers (or "C" papers, as the case may be), not to explore ideas. Even with open-formats, the grade remains the first thing students look at when the paper is returned.

Instead, grades are removed from papers. Papers now need to be "accepted". They can be resubmitted as many times as the student wants until they are accepted. It is important to note that this is *not* a pass/fail system, with acceptance being defined by a minimum grade. Instead, acceptance is determined by what the student gets out of it. An "A" quality paper might be sent back if interesting questions remain to be answered, while a "B" quality paper may be accepted if the student has exhausted all avenues and clearly learned something from it. As for grading, acceptance means full credit. The eventual grade is based on the number of papers accepted over the semester. For example, a course could have 100 points set aside for short papers. Each of the first three accepted papers could count for thirty points, while the fourth could count for ten points. Those students who want to do the minimal work would need to have only two papers accepted (60% of the possible points). Those who wish to put more effort could ensure three papers were accepted (90%), and those who really want to put in maximal effort could work on all four (100%). Removing the grade, and insisting students generate a paper that shows what they found interesting about the material turns the paper from a game of "produce what the teacher wants" to a more intrinsically rewarding experience.

"Benefit" Points: Mutual Assignment by Student and Teacher

Many teachers assign points based on "class participation". Again, this practice turns the classroom into a competition with a single goal: talking to get a good grade. Students then compete to "out talk" each other. In extreme cases, the quality of the comments is ignored, as teachers simply check off which students spoke. "Benefit" points, on the other hand, are assigned based on how much the student's presence *benefited* the class. Talking too much

(dominating) is not rewarded; nor is talking without saying anything. Listening and actively reacting to other students is ideal. Points can also be earned in other ways, as there are many ways to benefit the class. Feedback is often beneficial, whether a student gives it to the teacher about the course or to other students by reading their papers or helping them study. Students who explore topics outside of class and report also deserve credit.

The problem, then, is assessing the benefit. Specifically, how do teachers know all of these things and grade appropriately? The answer is, they don't, and don't have to. Half of the Benefit points are assigned by the student and half by the teacher. Both are blind assignments so that neither can "adjust" their score to take advantage of the other. This mutual assignment takes place at mid-term and final, and are not cumulative. This method allows students to learn to improve from their first half behavior, and does not allow those doing well to coast in the second half.

Students must justify awarding benefit points over 70% of possible. They are given structured guidance on how to assign points (e.g., clear expectations and explanations, handouts, behavioral profiles of what point assignments would look like, etc.). This way, teachers have an outstanding opportunity to get feedback on the course, to give feedback in a one-on-one private setting, and to re-focus students on exactly what is expected (i.e., after mid-term). This feedback also increases students' perceived control in class, which has been shown to yield positive benefits (Langer 1975). Additionally, as assignment of their grade leads to control over their grade, they can increase their self-efficacy for learning in the classroom, which also can increase their effort and performance (Bandura 1977). It allows them to tell their story, and treats them fairly, which leads to greater satisfaction (Cropanzano & Folger 1989). We've attached some examples of Benefit point assignments at the end of this paper.

Center on Quizzes: Intrinsic Motivation with Extrinsic Priorities

No matter how distasteful testing may be, it has an inevitable place in most classrooms. Many students need some external pressure to keep them current on the material, and some simply will prioritize what they have to do based on what is due. Still, the Collegial Classroom System attempts to redirect motivation in testing by centering on quizzes. Students come into class and take a short quiz *before* the lecture begins, so students are motivated to read *before* class in order to pass the quizzes. Reading is a high priority due to the external reward/punishment, yet the payoff is small as each quiz counts for little of the overall grade. In this instance, cognitive dissonance may occur as students are unable to resolve the discrepancy between doing a lot of work for a small reward, perhaps deciding that intrinsic motivation was also involved in their decision to study (Festinger 1957). Students are allowed to ask questions before each quiz which helps them learn to recognize what they *don't* know. This question and answer period can serve as a review session, which tends to benefit those who have read the most.

The quiz does not end there, as traditional quizzes often do. Once the students finish, they retake *the same quiz* in groups of three (if possible). This group-retake allows students to engage in active learning through meaningful discussion. Their attention is focused at a higher

level, as they listen to, and interact with, peers, rather than an authority figure. In short, students teach each other and better integrate the material. Other advantages are that students learn to work in groups with a focused goal and objective criteria. They also learn *not* to win arguments but to find the best answers.

The final part of the quiz process is that the class reviews the quiz in an *active* manner, where answers are not hard and fast, allowing students to explain their positions and debate the issues. By demanding support before an alternative answer is accepted, teachers help students learn the difference between evidence and opinion. The final grade on the quiz is a weighted average between the individual's initial performance and the group retake (e.g., 75%-25%, 67%-33%, etc.). This grade scheme retains the focus on the individual's work (i.e., students can't get away with not studying and relying on the group to pull them through), but adds the value of the group work.

Practical Concerns of the Collegial Classroom System

Switching over to the *ABC's* of the Collegial Classroom System is not at all simple for teachers. Perhaps most difficult hurdle is adapting to a new teaching role. Teachers lose some of their "teacher" status, as the system de-emphasizes traditional classroom leadership. They also need to learn new teaching skills (e.g., facilitating as opposed to lecturing). Additionally, teachers who choose this path will be going against much of the system in place at their institutions. Emphasizing *education* over grades in one classroom is exceedingly difficult when the "education" system as a whole does not. One has to constantly convince students that this class is different. With luck, their attitudes will change and carry over to their other courses.

This method may also be time consuming. The quizzes often take up entire class periods (but teachers will have extra time as they will no longer need to lecture on the basic material, or what the students should have read but didn't). Teachers must dedicate time outside of class to create quality quizzes that address important concepts, and challenge students and provoke them into debate (i.e., they can't test only simple knowledge; "why" questions are inevitably better than "what" questions). Teachers also have to dedicate increased time to grading the quizzes and assigning the Benefit points, as both take a great deal of effort. The Benefit points, however, do have additional payoffs as they serve as direct feedback from students about the course. Teachers will *save* time with the Accepted/Not-accepted papers. Assigning a binary variable (accepted/non-accepted) is much more efficient than assigning a grade and ensuring that it is commensurate to all the other grades assigned in the course.

One final problem that has not yet been addressed by the Collegial Classroom System is that of large classes. To this date, work has centered on classes of less than twenty students. While it is certainly possible for the above ideas to be adapted for larger enrollments, the time commitment could prove daunting. One answer that would be effective for larger courses might be to have the *ABCs* implemented in smaller sections of a large lecture. If sections are impractical, or if teachers do not wish to give up precious lecture time for sections, we remind them of what should be their goal: "It's not what you teach, it's what they learn."

Conclusion

Technology is not intrinsically incompatible with the Collegial Classroom System or the larger Learner-centered Education paradigm. However, like any other teaching technique, technology may be harmful if it shifts focus away from learning. Technology, like any other teaching technique, is bad if it shifts the focus away from learning. If the goal of teachers is to "inspire intellectual curiosity," then we need to focus on students and their perceptions of, and motivations in, their courses. Teachers need to change classroom atmospheres from competitive to collaborative. The Collegial Classroom System examines three primary ways to accomplish this (ABC). All three allow students to demonstrate knowledge in individual ways, and allow students to become intrinsically motivated by the material and by education, not by external grades. A final thought by Ralph Waldo Emerson highlights just how far away we are currently from the ideal: "If the colleges were better, if they really had it, you would need to get the police at the gates to keep order in the onrushing multitude.... Scholarship is to be created not by compulsion, but by awakening a pure interest in knowledge." (Noble 245)

Exemplars for Benefit Point Ratings

< 70% (you *could* be a body w/out a mind): you showed up in class, but didn't offer anything. You rarely did the reading before class and rarely, if ever, added to the discussion. When I finally called on you, you usually were unable to answer the question. You didn't use any of the ideas outside of class and basically didn't learn anything. For the most part, this class was a waste of time.

70-75% (you *could* have some mind inside your body): same as above, but you were able to sometimes add to the class. You usually read or skimmed and sometimes added your comments and insight. When I called on you, you were sometimes able to answer the question or add a useful comment. You thought about some of the issues outside of class, but weren't able to apply them much. For the most part, the class was better than noon meal formation.

76-80% (you *could* be a student): your presence in class was sometimes valuable as you often came to the class having done the reading, or at least skimmed the material. You were attentive in class and listened to other students. When the topic interested you, or when I called on you, you were able to share your insights. Some of the issues stayed in your head after class ended, and you even tried out one of the ideas. For the most part, it wasn't a bad class and you may have even learned something.

81-85% (you *could* be a behavioral science major): your presence usually added to the class. You usually did the reading and came to class prepared to talk and to listen, and to add what your insight was to the course. You thought about the course outside of class, and were willing to try out certain ideas. For you, it was a good class that gave you some real benefits.

86-90% (you *could* be a human behavior track major): your presence almost always added to the class. You almost always did the reading, and skimmed when you didn't have time in order to be prepared. You thought a lot about of the course, and tried out ideas outside of class whenever it seemed appropriate. Along the way, you did something that made this course a little better, and along the way, this class gave you something that made you a little better.

91-95% (you *could* be a social psychologist): your presence benefited the class, and helped other students think more critically about the material by bringing up your own unique perspective. You always did the reading and often thought about what it meant to you in your life. You weren't afraid to voice your opinion, or afraid to be wrong. You sometimes sought out other students to discuss your thoughts after certain lessons that were of particular importance, and offered to help them or get help on any assignments. You worried about the ethical implications because you were so likely to try out interesting ideas that came up. This is one of those classes you'll always remember because you really got involved.

96-100% (you *could* be Kurt Lewin's student): Your presence and questions not only benefited the other students but also made the instructor think about things in different ways. You always did the reading, even when there wasn't a quiz, and almost always thought about what it meant. You came to class with ideas and questions about what and why the material was being taught. You were able to not only provide your own unique perspective, but also able to release that view and look at ideas using multiple perspectives. You usually sought out other students to discuss your thoughts and possible applications. Using the ideas that were discussed outside of class seemed like a natural extension of the course. When you thought you had a good idea to improve the class, you would bring this to the instructor's attention. This is one of the classes that helped define your thoughts about what it is to be an officer and a leader.

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Concurrent Session Speakers' Biographies

Lieutenants Stephen Matthews, Thomas McIntyre, Jonathan Taylor, Rob Williamson, John Boehm, Brandon Rasmussen, Adam Sitler, Kevin Patrick, and George Wyse were all members of Dr. John Bertin's Aeronautical Engineering 481 Senior Design class. This particular year-long section was given the opportunity to be involved in the Air Force 2025 study to investigate how best to address the potential threats the Air Force would face in the future. The cadets were briefed on air force missions, technology requirements, and programmatic challenges. From these briefings and their research, the cadets completed this study and presented oral briefings to Lieutenant General Kelly, Air University Commander, to Dr. Hans Mark (the former SECAF, and former Chancellor of the U of Texas system), and to Dr. Gene McCall, the head of the Air Force Scientific Advisory Board. The paper was presented at the American Institute of Aeronautics and Astronautics conference in Norfolk in November 1996 by then Second Lieutenant Steve Matthews.

Upon graduation, all were commissioned Second Lieutenants in the USAF. Of the nine new lieutenants, seven received pilot assignments and two were assigned to graduate school: one at Massachusetts Institute of Technology, the other at the Air Force Institute of Technology.

Lieutenant Colonel Richard Sutherland, Director of Research, Department of Foreign Languages, USAF Academy, was first assigned to the USAF Academy in 1984, where he began working with videodisk technology to enable instructors to take advantage of this medium in their classrooms. With the advent of Internet and the World Wide Web (Web), he became actively involved with education in the state of Colorado and was a member of the team to provide access to every community in the state. Lieutenant Colonel Sutherland completed his doctoral work with M. D. Merrill at Utah State University in 1991 (where he was honored as "Outstanding PhD Scholar in Instructional Technology") after which he returned to the USAF Academy. Presently, Lieutenant Colonel Sutherland is concentrating on the integration of full-motion, digital video, Internet, and the World Wide Web into high school and college classrooms. He is also refining methods for using Internet materials off-line and for transferring entire archives from Internet to distribute via CD-ROM.

Colonel Cary Fisher received his bachelor's degree from the United States Military Academy, a master's degree in aeronautical engineering from the California Institute of Technology, a master's degree in political science from the University of New Mexico and a PhD in mechanical engineering from the University of Oklahoma. In addition to his long tenure as an Air Force Academy professor, Colonel Fisher has served as an engineer and program director at the Air Force Weapons Laboratory, as a weapons controller and senior director during the Southeast Asia conflict, as Chief Scientist with the European Office of Aerospace Research and Development, and as a science attaché in the American Embassy in London. Colonel Fisher is active in the American Society for Engineering Education, having just completed his service as president. He has also served in various capacities within the American Society of Mechanical Engineers to include National Chairman of the Mechanical Engineering Department Heads Committee. He is a registered professional engineer in the State of Colorado.

Lieutenant Colonel (Retired) Richard Lemp is Professor of English at the USAF Academy. First appointed to the Academy faculty as in 1976, Dr. Lemp received his BA from the University of Missouri-Columbia in 1971, MA from Washington University in St Louis in 1972, MBA from California State University-Dominguez in 1976, and PhD from the University of Arizona in 1986. Before retiring from active duty, Dr. Lemp had served as an Air Force officer for nearly 24 years, including 15 at the USAF Academy in the Departments of English and Foreign Languages. His special interests include French literature of the Renaissance and 17th century, and the literature of Quebec. He is also currently translating "La Troisième guerre mondiale n'a pas eu lieu: l'Alliance atlantique et la paix" by François de Rose for the National Defense University Press.

Dr. Lynne Schrum is Associate Professor, Department of Instructional Technology at The University of Georgia where she teaches distance learning, educational telecommunications, and research courses. Since receiving her PhD at the University of Oregon in 1991, she has written a variety of articles, monographs, and books on innovation adoption, online education, ethical electronic research, and fostering collaboration and interactivity in a distance learning environment. In addition, she is President Elect of the International Society for Technology in Education (ISTE), which represents 47,000 educators throughout the world. Her research interests include: interactive distance learning models; appropriate uses of educational telecommunications to enhance learning; online education and groupware; ethical electronic research and acceptable use policies; and the role of technology in school restructuring efforts.

Major Thomas W. Krise is a senior military fellow of the Institute for National Strategic Studies and vice director of the NDU Press, National Defense University, Fort McNair, Washington, DC. At NDU Press, he directs the electronic publication program, the main component of NDU's home page—a Point Top 5% Award-winner. The Press's electronic publications include: the annual *Strategic Assessment*, the *Strategic Forum* position papers, the McNair Papers monograph series, and various titles from the NDU Press book series. A former faculty member and graduate of the Air Force Academy, he holds a PhD from the University of Chicago.

Dr. Judy Holdener received her PhD in 1994 from the University of Illinois under the direction of Daniel Grayson. She then joined the faculty at the USAF Academy as an assistant professor in the Department of Mathematical Sciences. Her research interests include algebraic K-theory, calculus reform, and the use of technology in teaching.

Dr. Will Hochman is Director of Writing and Assistant Professor of English at the University of Southern Colorado, and is codirector of the Rocky Mountain Alliance for Computers and Writing. He has a PhD in English Education from NYU and has written and presented extensively on hypertext and other on-line learning issues. Hochman is also a poet—his most recent collection is *Stranger Within*.

Colonel Steve Chiabotti is a Distinguished Graduate of the Air Force Academy, Class of 1972. After graduation, he spent several years training Air Force pilots in the T-37 and T-41 aircraft. Colonel Chiabotti earned his PhD from Duke University in the history of science and technology and military history and returned to the Air Force Academy as an assistant professor of history. He was instrumental in establishing the Academy's current curricula in the history of science and engineering and the history of technology and war. In 1986 he won the William P. Clements Award as the Outstanding Military Educator in History. Following his teaching assignment, Colonel Chiabotti served as the Chief of Aircraft Program Management at Air Training Command Headquarters. He returned to the Air Force Academy to direct military history, fly the new T-3 aircraft, and manage the interactive multimedia Airpower Project.

Dr. Thomas C. Reeves is Professor of Instructional Technology at The University of Georgia. He has developed and evaluated numerous interactive multimedia programs and has been an invited speaker and workshop provider in Australia, Brazil, Bulgaria, Canada, Finland, Peru, Russia, South Africa, Switzerland, Taiwan, and the United States. In 1995, Dr. Reeves was selected one of the "Top 100" people in multimedia by *Multimedia Producer* magazine.

Lieutenant Colonel David A. Boxwell has been a member of the English Department at the USAF Academy since 1989, teaching literature, composition, speech, and media affairs. He assisted in the teaching of a survey course on American cinema at the Academy in 1996.

Dr. Evelyn T. Patterson is an Associate Professor of Physics and Director of the Center for Physics Education Research at the USAF Academy. She received her BS degree from Bucknell University, where she majored in Physics and minored in Music. She earned her PhD in experimental cosmic ray physics from the University of Delaware, where she worked with high altitude balloon and satellite experiments. Dr. Patterson joined the faculty of the USAF Academy in 1993. At the Academy, she teaches cadets and is involved in a number of physics education projects, while continuing to do some cosmic ray physics research. Her educational interests broadly include the use of technology to improve teaching and learning.

Colonel David B. Porter is Permanent Professor and Head of the Department of Behavioral Sciences and Leadership. He was a Distinguished Graduate of the USAF Academy, earning a Bachelor of Science degree in Engineering Management in 1971, a Master of Science degree in Industrial Relations from the University of California at Los Angeles in 1972, and his doctorate in Experimental Cognitive Psychology from Oxford University in 1986. He is a senior pilot with over 1400 flight hours and has taught on the faculty at the USAF Academy for two tours, 1979-1981, and 1986 to the present. He officially assumed his duties as Permanent Professor and Head in October 1996.

Dr. Steven M. Samuels is Assistant Professor of Behavioral Science at the USAF Academy. He earned his BA from Brandeis University in Psychology and Philosophy, and his PhD from Stanford University in Psychology, specializing in Social Psychology, with a focus in Business. He was named Stanford Center for Conflict Negotiation fellow in 1992. He was one of the first twelve civilians hired to integrate civilians into the USAF Academy faculty and has since been awarded Teaching Excellence and Civilian of the Quarter awards. He has taught Introductory Psychology, Social Psychology, and Negotiations, at the Academy.