# PROFESSIONAL MILITARY EDUCATION (PME) IN 2020

The effective employment of air and space power has to do not so much with airplanes and missiles and engineering as with thinking and attitude and imagination.[1]

> - Gen Merrill A. McPeak

Visionary and innovative thinking is not just reserved for senior leadership; but must be understood and practiced at every level for an organization to continue to thrive.[2]

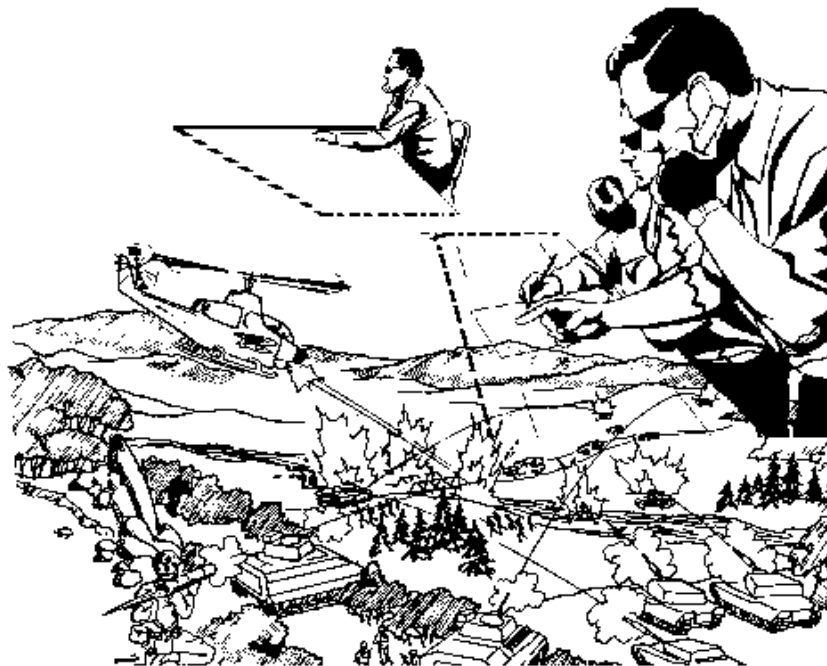> - Air Force Quality Institute



**Figure 1.  Virtual Lessons**

## Subject and Problem Statement

As muscle work declines, large numbers of unskilled laborers are increasingly replaced by smaller numbers of highly trained workers and intelligent machines. ... This process, too, is perfectly parallel in the military, where smart weapons require smart soldiers. ... The idea that the Gulf War was a 'high-tech' war in which the human element in combat was eliminated is a fantasy.  The fact is that the forces sent by the allies to

the Gulf were the best educated and technically expert army ever sent into battle. ... The new military needs soldiers who use their brains, can deal with a diversity of people and cultures, who can tolerate ambiguity, take initiative, and ask questions, even to the point of questioning authority. ... The willingness to ask and think may be more prevalent in the US armed forces than in many businesses. ... As in the civilian economy, fewer people with intelligent technology can accomplish more than a lot of people with the brute-force tools of the past.[3]

<div align="right">-- Alvin Toffler</div>

**Introduction**

PME 2020 will be a residency program, but it will evolve to become a residency program unlike any that exists today.  It will encompass all of what currently constitutes military education and training.  This program will develop from today's distance learning, multimedia, virtual reality, and telepresence concepts.  This paper discusses the evolution of PME.  First, the paper describes why the PME system must change.  Second, the paper explains how the PME system will change.  Third, potential technologies are highlighted.  Finally, this paper identifies the emerging technologies and operational exploitation opportunities.  Annex A of the paper recommends ten steps that should be undertaken today to ensure the continuation of a successful PME system in the future.  Annex B answers the questions of what the future curriculum will include and whether multimedia and virtual reality will fit into PME 2020's curriculum.  The "Glossary" contains key terms used throughout this paper.

The virtual resident program of PME 2020 will link highly integrated telecommunications with virtual reality.  This future program will ensure the war fighter is able to overcome the challenges posed by the operating environment of the future.  These challenges include the informational and technological explosions, smaller armed forces, fiscal constraints, and the technological environment.  PME 2020 will overcome these difficulties and will guarantee that war fighters are able to perform their role in national security.
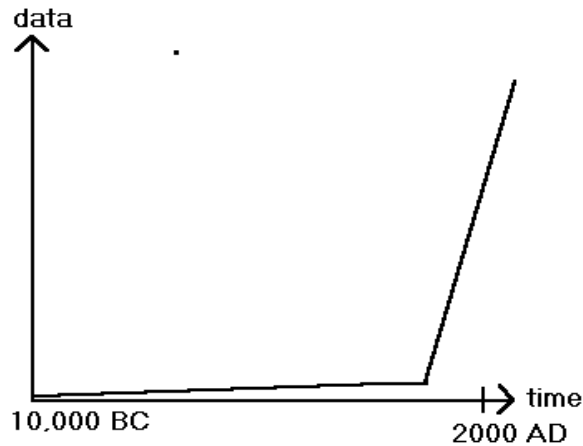
**Figure 2.  Information Growth**

**Informational And Technological Explosion**

The rate of change in technology and the rate of growth in available information are increasing every day.  As the American military increasingly depends on technology and information to both deter and win war, the military member must understand both and  use them as the force multipliers upon which the nation has come to depend.

Space, a critical element in any future vision of the US military, provides many examples of the current and coming information explosion.  One system of satellites alone, set to launch in 1998 - 2013, will generate more than 10 quadrillion bytes of information about the Earth, "equal to about 10 billion books (Library of Congress holds a mere 27 million)." [4]  The "Clementine" mission, now underway, is sending back 10,000 times the imagery of its predecessor.[5]  "But sending data-collecting satellites spaceward is only half the task.  Storing, analyzing, and rapidly disseminating the information once it is sent back will prove equally difficult."[6]  "The helical scan storage technology NASA currently utilizes stores 45 terabytes [equal to 500 million pages of information] on top of a desk."[7]  How will future military analysts quickly determine and locate the critical information which can mean life-or-death and success-or-failure in the combat environments of 2020?  The military education system can help analysts and operational units by determining which methods and technologies will be needed.  PME 2020 must prepare the future war fighter for these informational and technological explosions.  Information itself could be the next battlefield.

**Figure 3.  In the Mind's Eye**

**Personnel Changes**

By the year 2020, the characteristics of military members will be significantly different than they are today.  In particular, fiscal constraints will continue to impact  the number of military members who will attend or enroll in PME.[8]  First, there will be fewer military personnel of all ranks in 2020.  Accordingly, the impact and cost (including opportunity cost) of attending in residence will be higher because there will be fewer people to fill in for anyone going TDY or PCS to school.  Second, personnel will be at scattered locations in the US and abroad, locations which may be very different from those today.  Third, there will be fewer personnel of senior rank, officer and enlisted, at any one location.  This means both a higher opportunity cost incurred for those who must leave the unit for education or training and also less chance of finding enough people of a given rank to constitute a face-to-face on-location seminar.  PME 2020 must be able to accommodate this smaller, geographically separated military force that may not be able to afford the opportunity to attend lengthy and costly resident PME.

In addition, the characteristics of 2020 PME students will be different from those enrolled in PME today.  In 2020, students will be more familiar and comfortable with technology.  For example, they will have grown up with virtual reality in the home and school.  Personnel will also be familiar with the blurring between work, education, and home life and with the multiple careers and diverse demands on workers of 2020.[9]/[10]

Figure 4.  Declining Budgets

**Fiscal Constraints**

Military budgets, as a percentage of real GNP, will continue to get smaller in the future.[11]  There will be less money spent on travel than now.  This infers fewer TDY's and PCS's to attend PME and other specialized training.  There will be less money for many kinds of equipment and infrastructure.  As the military appropriation tracks downward, costs for technological capability (desktop, especially) are falling between 30 and 68 percent per year (and appear to be able to do so indefinitely).  Therefore, fiscal constraints will mean increased use of technology to cover for personnel who are traveling or whose jobs have been automated or eliminated.  PME 2020 should be able to better educate more people with fewer dollars.
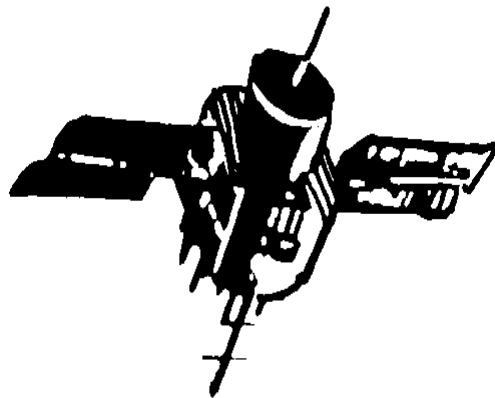
Figure 5.  Applied Technology

**Technological Environment**

The technology environment surrounding military members will be very different than the one today.[12]  Even assuming no revolutionary breakthroughs, unlikely though that is, and only maturation of existing technologies (meaning anything currently in use,

planning, or research), the technology environment of 2020 will be a rich one. It will include commonplace use of artificial intelligence, intense miniaturization, expert systems, virtual and artificial realities, and automated "computer assistants." PME 2020 must harness this technology to better educate the entire military force.

**In Summary**

PME must respond to current and continued changes in the information and technological explosion, military characteristics, fiscal constraints, and changes in the technological environment. Consequently, PME 2020 will have an entirely new look, feel, and responsibility. More importantly, PME must begin changing now to ensure it maintains capability and relevance to positively impact the future war fighters and guarantee their ability to contribute to national security. This paper will focus on the impact of each of these areas while discussing PME's current and future capabilities and relevance to war fighters.

## The Capability and Its Relevance

"If we should have to fight, we should be prepared to do so
from the neck up instead of from the neck down."
- Jimmy Doolittle

**Introduction**

"Virtual residency" is the linking of telecommunications and computers in PME 2020. While the present PME system may be adequate today, it will not be adequate in the future without significant changes. PME must have new and different capabilities to meet the military challenges in 2020 and beyond. First, PME 2020 must respond to the information and technology explosions by teaching the war fighter how to navigate the information highways. Second, the system must deal with the personnel changes and challenges by, 1) tailoring education to individual needs, 2) contributing to retention of the best-qualified personnel, 3) capitalizing on an enlarged technology comfort zone, 4) being aware of society's falling educational standards, 5) taking advantage of the changing work environment, 6) aiding productivity and innovation, and 7) realizing every military member needs quality PME. Third, PME 2020 must thrive within fiscal constraints by improving results while reducing costs in money and time. Fourth, the system must maximize the technological environment by keeping every military member

"connected." Fifth, PME 2020 needs to broaden its horizons by becoming an open system which educates everyone (including potential adversaries), with a curriculum that is continuously updated and distributed using enhanced distance learning methods, known as virtual residency in PME 2020. Finally, the questions raised by critics about the proposed PME 2020 system will be successfully answered.

**Responding To The Information And Technology Explosion**

By 2020, information needs will grow exponentially and the amount of new information will be astronomical. Without careful planning and information-handling skills, the decision-makers of the future will be susceptible to "analysis paralysis."[13] Estimates show new information will double every few weeks (or days) due to quantum leaps in technology and the number of people using it. Instant access to the Information Super Highway, the Library of Congress, and numerous other sources worldwide will create an information overload almost unimaginable today. The technologies and techniques associated with the PME 2020 system will aid the war fighter when navigating the information highway.



**Figure 6. Information Compass**

Learning To Navigate

Information navigation (searching) skills, will be critical for all who expect to navigate the rapidly increasing sea of information. PME 2020 problem-solving techniques will emphasize the skills required to narrow the search for critical information in the aircraft, ship, or tank. The PME system will be much more adaptive, enabling it to respond to this ever-increasing and changing world of information. PME 2020 's theme is capsulized in the statement, "knowing the knowledge terrain will be as important for

Third Wave armies as knowing the geography and topology of the battlefield was in the past."[14]

**Dealing With Personnel Changes And Challenges**

PME 2020 will be divided into smaller blocks of instruction which address the specific needs of individuals without regard to rank or position.  In addition, PME will be accomplished more quickly and efficiently ensuring the military member keeps pace with the information explosion.  PME will respond by building comprehensive lesson systems which will teach a broader range of skills.  PME will also expand its individualized educational outlook, by including basic level training in many general areas, while providing specialized training in a more narrow range.[15]

Tailoring Education To Individual Needs

PME 2020 will be an individualized, self-modifying education system responding to the learning modes of each student.  It will adjust its courses and the answers it provides to questions as the data changes from day-to-day.  Faculty will be able to concentrate on instructing at higher levels of learning and developing courses for entirely new areas of instruction.

PME 2020 will ensure students understand the technology of 2020 by incorporating on-the-job training (OJT) for systems specifically needed to accomplish their mission.  PME 2020 will provide the means for transferring this specialized or general OJT directly to the war fighter by "beaming" it into aircraft, tanks, or ships.

Individuals thus trained will have the flexibility to be stationed wherever needed and know the job requirements or be capable of learning them quickly.  PME 2020 trained individuals will become a "force multiplier" to the military.

Recruiting And Retention.  Keeping The Best Qualified

PME 2020 will directly contribute to recruiting and retention.  The virtual reality, computer simulations, and telecommunications technology associated with PME 2020 will attract those interested in state-of-the-art technology.[16]

> As we downsize our military, there is a critical need to prevent any decline
> in the readiness of our armed forces.  As forces and budgets shrink, there
> is the danger that training and maintenance will suffer.  The increasing
> frequency and duration of deployments will eventually make retention of
> high quality personnel more difficult.[17]
> > -- Policy Letter from the Secretary of the Air Force

The level of technology represented in PME 2020 and the ability for personnel to be in contact with virtual seminars and research groups and to continue instruction, even while on deployment to remote regions, can aid retention.  Research results indicate the environment and opportunities of PME 2020 should be conducive to retaining technologically-oriented individuals.[18]  How can the military apply these results to its education system to keep the best of its people?  A virtual reality PME 2020 system linked through telecommunications will provide the forum for all interested students to work on high priority, real-time projects.  This will help to recruit and retain the best-qualified personnel for the military.

Enlarged Technology Comfort Zone

To meet the future challenges, PME must also take advantage of the changing characteristics of its people.  The pre-adult environment of 2020 military recruits will have habituated them to technology and to more readily accept technological changes.  The current 20-something generation already considers itself "masters of technology" and "use computers the way other generations use the phone."[19]  Succeeding generations will be even more technologically sophisticated.  Regarding the shift to interactive simulations for training, Gen Carl E. Mundy, Marine Corps Commandant, stated:

> ...it's very exciting for these young people, sitting down to work in arcades
> like they have in shopping centers.  The Stinger (missile) trainer, for
> example...It's fun ... It (increased use of simulations) will save us a lot of
> money in the long run.[20]

PME 2020 will capitalize on the skills the students bring to it.  Virtual reality, telecommunications, and computers will be nothing new or threatening to the students and faculty of PME 2020 -- although there will be a transition period to reach that time required to make the adjustments.

<u>Expectations Regarding Knowledge And Learning Skills</u>

In 2020, war fighters raised on the successors to Nintendo and MTV may expect instantaneous answers to their questions, but they may or may not join the military with the necessary skills to use that information.  The current college generation is characterized as "victims of declining educational standards ... Three quarters of college professors say students are 'seriously unprepared' in basic skills."[21]   This may still be a problem in 2020.  PME 2020 must be able to respond to the education and training needs of these individuals.  A system that provides access to all resources at all levels to all students is the best method to counter any problems with basic skills.  PME 2020 will be just that.  A military-wide, virtual residency system both flexible and resilient may be the best means to set, maintain, and enforce standards in education.

<u>The Changing Work Environment</u>

PME 2020 will have to respond to the changing work environment.  Increasing numbers of challenges such as new warfare forms, combined with a technical environment which is, in the words of General McPeak, "dynamic to a degree different from anything in human experience," and which when added to our "getting smaller quite quickly," will mean  our people will have to be "more comprehensively trained, less specialized," and will have to cycle back through school often during their careers.  They will need a "broader range of skills," in order to be "more flexible."[22]   Virtual residency will provide the means for military members to accomplish those ends.

Part of the building of the PME 2020 system should include implementing a change in the workday/workweek paradigm to include scheduled sacrosanct times (similar to the "Minuteman Education Program") for individuals to attend PME 2020 courses.  Commanders must make the commitment to education and training to ensure time is set aside.  PME 2020 must be as easy to schedule and attend as a staff meeting, including coordinating times for "virtual" seminars with members at geographically-separated locations.

Synergistic Effects

The telecommunication aspect of PME 2020 will provide PME connectivity to every military member.  This capability will allow individuals to broaden their expertise and become educated in areas outside of their primary career fields .  Additionally, the potential exists for unique combinations of backgrounds and interests working within the system on the same project.  This interaction will increase productivity and innovation in the military by enabling creative minds to maintain and act in what should be a dynamic educational and training experience.

> ...if you asked a panel of experts in a field when something was going to happen, they were much more conservative than a counter-group of experts from another field outside the topic because the outsiders were less tied up in the immediate problems.  They could see the bigger picture ... So, the most interesting things I hear about economics do not come from economists, they come from psychologists, or from geneticists.  And the same thing would be true in reverse.  The most interesting things economists say have little to do with economics.
>
> I believe that we're moving toward a world of multiple careers, which means that we may eventually branch out after many years in one field. Instead of a lifetime of specialization in a single topic we shift to another. We may lose the benefits of deep specialization, but we will gain the advantage of creative insight and analogy from one field to another.[23]
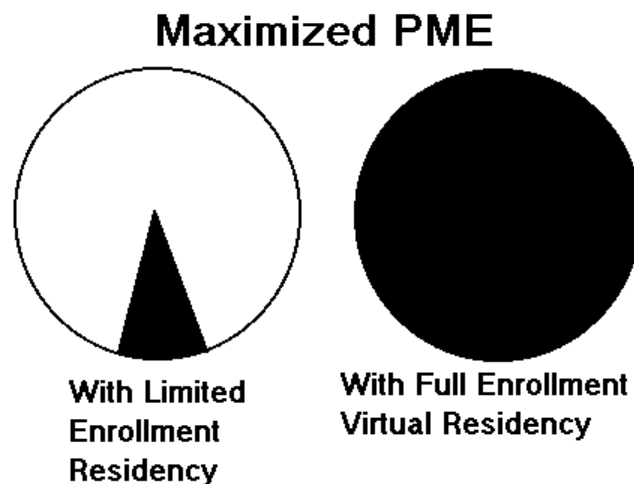> -- Alvin Toffler



**Figure 7.  Maximum Opportunity Realized**

Who needs PME?  Everyone.

> Nearly everyone seems to agree, however, that the strength of today's force lies not only in the strategic acumen of its senior commanders, but also in the demands placed on those leaders by an astute and inquisitive rank and file.  "Whether you're talking about a general or a lieutenant, military leaders today are challenged by bright capable soldiers who ask tough questions," says Rep. Skelton. "Gone are the days when a Gen Custer could tell his soldiers to get on their horses and ride without ever having to explain why. Maybe he SHOULD have had to explain."[24]

PME 2020 must constantly educate every military member.  As Tom Peters states, in his book *Thriving on Chaos*, we must:  1)  invest in human capital as much as in hardware, 2)  train entry-level people and then retrain them as necessary, 3)  train everyone in problem-solving techniques to contribute to quality improvement, 4)  train extensively following promotion to the first managerial job; then train managers every time they advance, and 5)  use training as a vehicle for instilling a strategic thrust.[25]

This need to have a better-educated and trained force requires all military personnel receive their education and training through a quality PME system.  The PME 2020 system will continue the "seminar" experience through "on-line" seminars and virtual residency.  During the transitional years before virtual reality technology matures, virtual seminars will initially meet via video teleconferencing centers at their home units. All groups in the PME 2020 system can share in these on-line seminars.  This virtual residency system also provides for contacts across rank lines, between services, and among the civilian world.  The virtual residency concept of the PME 2020 system will become the norm.

**Living Within Fiscal Restraints**

PME 2020's potential accomplishments are limitless however, dollars required to educate and train war fighters are finite.  Fiscal constraints must be considered and accommodated.  For example, due to fiscal constraints, there will be fewer high-priced weapon systems developed and more frequent, incremental, technological upgrades to existing systems.  This will require frequently rethinking uses of the systems and retraining users -- i.e., the war fighters and their support personnel.  For this, the virtual reality learning environment is ideal.  Even beyond this (or before it), "simulate before you build" is becoming a military principle -- virtually exploring the problems, benefits,

and trade-offs of training people to use the new system, educating leaders in employing the systems, and experimenting with possible counter-measures and limiting factors.[26]
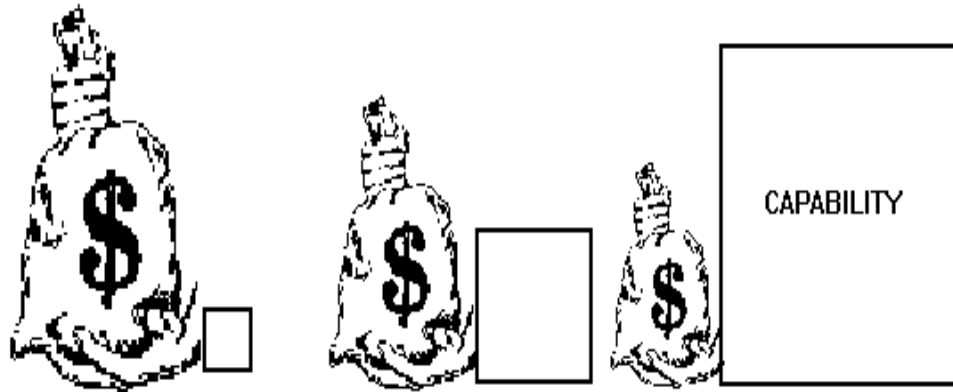


**Figure 8. Buying More With Less**

Reduced Cost With Better Results

PME 2020's use of interactive technologies for delivery of instruction will reduce costs and improve results. Studies demonstrate as much as 50 percent or more reduction in time needed to learn, compared to conventional delivery.[27] Digital Equipment Corporation reported saving 40 percent of training time by using multimedia instead of traditional classroom teaching. IBM marketing education division reported time savings of 40 percent.[28] Federal Express saved 60 percent of training time.[29]

IBM is a prime example of how the interactive technologies will reduce military costs and provide better results. It reported an overall savings of more than $150 million per year, with much of the savings coming from 300,000 employees not traveling to receive their instruction.[30] The military will see similar dramatic savings by eliminating much, if not all, of the physical residency requirement for courses -- and thus eliminate much of the TDY, moving, dislocation, per diem, and other costs of students attending resident courses lasting from several days to 10 1/2 months. Virtual residency has the potential to train more military members, more effectively, for less.
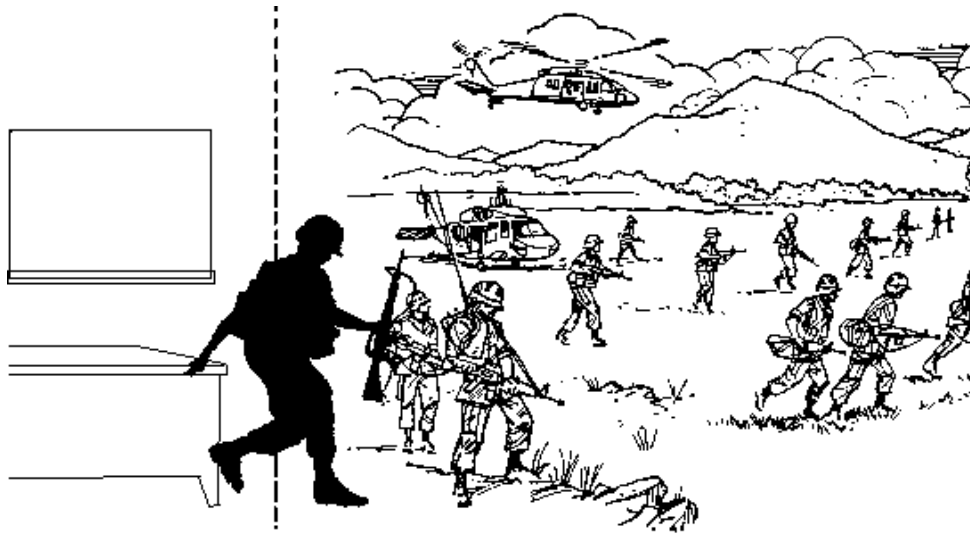
**Figure 9.  From the Office**

Need For Nonresident Education - Virtual Residency

Shrinking budgets will reduce military forces and other DOD resources by 2020. Those reduced forces will still be widely distributed in the CONUS and overseas, but in fewer locations.  Consequently, there will be fewer personnel available overall and at fewer locations to participate in PME as students, faculty, and course authors.  With fewer human and materiel resources, the value of each will increase.  This will place a premium on more effective educational and training programs.  For example, by the end of a 20-year career, an Army officer today may have spent more than five years in the classroom.[31]  It is doubtful, with the limited personnel of 2020, whether the military will be able to tolerate losing individuals from operational locations for 25 percent of their careers.  The costs of sending personnel to resident PME programs (including time lost from their operational jobs) must lead the military to reexamine the benefits of attending resident courses -- and to look for viable alternatives, such as PME 2020.  Enhancing the PME system, in spite of fiscal constraints, can be accomplished by converting to a solid, adaptable, virtual resident education and training program.  Virtual residency is the most effective and efficient method to maintain high standards of military education, especially with respect to rapid changes in technology and doctrine -- changes with which the military must constantly stay abreast.

**Maximizing Effectiveness In The Technology Environment**

All 2020 military personnel will be "connected" to data bases through wide area networks such as Internet.  By the middle of 1993, Internet alone was already interconnected with over 15,000 other networks and over 20 million primary users.[32] Internet's membership is currently growing more than 20 percent per month.[33] Regardless of unit location, military personnel will have access to worldwide information networks capable of two-way data, image, and simulation transmission.  PME 2020 must remain flexible to take advantage of this situation and be brought closer to the individual on a daily basis to ensure education or training requirements are met.



**Figure 10.  Virtual Classroom 2020**

Connectivity Is The key

> 'What telecommunications does is to remarkably expand the quantity and quality of information resources that can be in a classroom,' says Linda Roberts, a senior associate in the Science, Education, and Transportation program at the US Congress's Office of Technology Assessment.  'And by 'information resources,' I'm not just talking about what's written down or what's stored in a digital world -- I'm talking about the ability to work with other classrooms, to expand the community of learners, and to have real access to people who know something, whether that means scientists in research laboratories or people in the business community or politicians who are grappling with decisions.'
>
> ... demands on the 21st-century work force are likely to include not just familiarity with computing, but a capacity for cooperative learning, both of which are fostered by educational networks.[34]

For individuals to take advantage of this new concept of an integrated and flexible job and education combination in 2020, all military personnel will need to be electronically "connected" to the PME system.  Furthermore, PME 2020 will be available to all personnel, including those working in remote locations or at sea.

For Faculty as Well

The telecommunications aspect of PME 2020 will also have a positive impact on the faculty. Edward Mabry, a communication researcher at the University of Wisconsin, highlights this concept:

> Historically, the strength of an academic department rested with its resident faculty. Now it depends on the extent to which each faculty member is interconnected with other professionals -- worldwide -- pursuing similar interests. And these associations do not rely on face-to-face contact. We now have electronic research teams and electronic water coolers.[35]

A study by Carnegie Mellon University, analyzing interaction and productivity of scientists in the area of oceanography, also supports this concept:

> Frequent users (of networks) are the more active, productive scientists. Scientists who use the network more also produce more papers, receive more professional recognition from their peers, and know more (other)... oceanographers.[36]

The faculty, as well as the students, of PME 2020 will directly benefit from the technologies incorporated into the system.

**Broad Horizons**

PME 2020 will be a two-way gathering and sharing between students and faculty while simultaneously building an infrastructure on the expectations and experiences from personnel at all levels. As General McPeak stated:

> Healthy dialogue is important to any organization. ... By the way, a healthy dialogue includes listening to opposing views inside the organization. Openness is a two-way, and often rough and tumble process.[37]

Open System

PME 2020 will be an open education and training program. To efficiently utilize military resources, information will be shared between services and with civilian institutions, especially in research and curriculum development. Military and civilian educational institutions have much to share that will benefit both. For example, history lessons might be developed by PME academies or civilian institutions and then shared between institutions. Current commercial CD-ROM's already include disks on almost every major war in US history as well as information on the space system and military aircraft. Military schools and other military organizations may find that their methodologies, information, and courseware have commercial value.[38]

Involving And Educating Others



**Figure 11.  The Class of 2020**

The telecommunications and open system aspects of PME 2020 will directly contribute to increased understanding and support for the military. PME 2020 will have the capability to reach larger audiences, such as the media, Congress, the public at large, and potential adversaries. It will educate the press to ensure they understand the military situations they cover, and are able to provide the public with balanced coverage, providing the military with constructive feedback. PME 2020 will educate Congress and other civilian leaders, helping them make fully-informed decisions affecting the military. PME 2020 will also educate the American public. A public, better informed on military capabilities, competence, and needs, will be beneficial for America, improving the chances of continued public support for the military. As Alvin Toffler observed:

> ... smart generals understand all too well that wars can be won on the world's television screens as well as on the battlefield. ... Media policy, therefore, along with policies for communication and education, will together comprise the main distribution components of any overall knowledge strategy. [39]

Educating Potential Adversaries

Finally, the telecommunications and open system aspects of PME 2020 will be available to educate our potential adversaries. Although select foreign officers already attend US military schools, including intermediate and senior service schools, this concept will be greatly expanded with most of PME 2020 open to military officers of all ranks from all nations -- in any location where they can connect with PME 2020. There are many benefits associated with this open concept. The war-prevention and negotiation processes may be easier with "informed" opponents. They may understand and perhaps begin to share our ideals and values. More importantly, they may begin to think and solve problems in ways familiar to us. Information gathered through the PME 2020 system may convince possible opponents of the benefits of non-lethal warfare. In addition, it will convince them that the US military is extremely competent and capable.[40]

Continual Timely Updates Of Curriculum

PME 2020 will be a truly up-to-date curriculum. First, since courses will be available on-demand, military members will be able to learn skills and find information when needed. Second, by establishing expiration dates on courses with time-sensitive material, PME 2020 will ensure currency is maintained and past graduates of those courses are cued to their need for refresher courses or repetition repeating of the original courses. Finally, for all courses, the course material will be continually, electronically updated.

Virtual Residency Is The Key

Virtual residency, with a core curriculum and consolidated resources, is the most important aspect of PME 2020. First, PME 2020 will have a core curriculum integrating land, sea, air, space, non-lethal, and information warfare. Second, the resources of PME 2020 institutions will be consolidated where practical and will be highly integrated electronically. Finally, virtual residency will be the main means of educational distribution. The move toward this process has already begun in the military. For example, the Air Force Institute of Technology (AFIT) began their nationwide distance education course in systems planning and management last year. Serving over 7200 students, it should have a cost benefit of $20 million over 6 years.[41] Also, AFIT has an ongoing Professional Continuing Education program, making use of satellite links

throughout the Air Force.  This type of distance learning, in addition to being more cost-efficient, will be more effective in accomplishing joint education and training.  More and more, the services are looking at sharing education tasks and resources to achieve those cost benefits, especially with distance education.[42]  In 1992, Maj Gen Larry Day, Deputy Chief of Staff, Technical Training, Air Training Command, stated,

> In the next decade, more and more training will occur away from traditional training sites ... The concept [distance education] will save on travel and per diem costs and should be a routine training technique for all the services within a decade... The effort [to share training across services] is led by a little-known group called the Interservice Training Review Organization.[43]

Furthermore, as previously discussed, reductions in faculty and other academic resources will necessitate increased sharing among the remaining military and civilian institutions, which will further advance the case for enhanced distance learning.  Virtual residency is a natural and needed extension of current distance learning methods and will ensure the success of PME 2020.

**Are There Objections?**

In considering objections and resistance to implementing these changes to the PME system, it might be well to keep in mind the words of Alvin Toffler:

> I think the main failure of culture is the failure of imagination.  It's very hard to think outside the boxes -- cultural box, institutional box, political box, religious box -- that we are all, everyone of us, imprisoned in.[44]

"Distance learning takes away from personal contact, the key value of PME."

First, even without the existence of the virtual reality of 2020, current connectivity has already demonstrated that interactive communication through electronic means may lead to even greater openness and understanding than face-to-face communication.  This is due to the entirely egalitarian nature of the interaction, which eliminates many of the intimidating and inhibiting factors of face-to-face in-the-same-room communication.  For example, one of the top "head hunter" executive recruiting firms, as a cost-cutting measure, in 1993 began providing video conferencing technology for client companies to use for interviewing top-level candidates, a situation where

"every nuance of face-to-face communications is crucial."  The vice-president of the recruiting company said they were surprised at how quickly client companies adapted.

> Initially we thought they would interview candidates and then fly in the final candidate, but in many cases candidates have accepted the job right over the ConferView.  They were more comfortable than we thought they would be.[45]

Interpersonal skills apparently are communicated over the electronic medium.  Coincidentally, the above firm estimates it will save clients $135 million this year in reduced travel costs.

Second, by 2020, virtual reality will provide the stimulus of co-location.  MIT already is working on computers which will read subtleties of facial expression and voice and duplicate them on computer-generated representations of individuals involved.  MIT researchers are even teaching the computer to recognize the difference between a genuine and fake smile.[46]

Third, the virtual classroom may be supplemented, at least at first, by a physical meeting of the participants.  This meeting will likely be of a short orientation nature.  For example, designated virtual seminar mates, spanning services and nations, may meet for two weeks of immersive orientation at the beginning (and perhaps annually) of a three-year virtual seminar course.  This physical meeting should enhance and personalize to the computer representations of each of the seminar members.  Even today's virtual reality simulators already allow participants to quickly dismiss any lingering artificialities.  Bruce Sterling reported on Army tank crews and their virtual reality experiences.

> Group by group, the dead tank crews filed into the classroom and gazed upon the battlefield from a heavenly perspective.  Slouching in their seats and perching their forage caps on their knees, they began to talk.  They weren't talking about pixels, polygons, baud-rates, Ethernet lines, or network architectures.  If they'd felt any gosh-wow respect for these high-tech aspects of their experience, those perceptions had clearly vanished early on.  They were talking exclusively about fields of fire, and fall-back positions, and radio traffic and indirect artillery strikes.  They weren't discussing "virtual reality" or anything akin to it.  These soldiers were talking war.[47]

"Distance learning (or virtual residency) reduces student interaction with the faculty."



**Figure 12.  Virtual Interaction**

The facts argue that increased connectivity will mean even greater interaction with faculty, with more efficient use of student and faculty time, by using multi-party interactive on-line or virtual conversations.  In addition, there will be increased access to experts not on the "resident" faculty, but merely available to answer questions in their particular area.  This is a critical aspect of PME 2020 when one considers future reduced numbers of military experts and reduced funds for hiring full-time civilian (including retired military) experts. Will PME schools and courses be able to afford full-time subject matter experts for each particular weapon system, culture, or strategy?  The virtual residency, expert systems, and telecommunications aspects of PME 2020 guarantee these experts, or at least their knowledge, will be available for the future war fighter on-demand.

Additionally, using virtual reality, students can talk with Caesar and Napoleon.  These "virtual" leaders will be programmed with all the anecdotes, paintings, photos (if available), film, video, and books about them.  MIT and other labs are working on programs to create "virtual" people that seem alive in virtual reality environments.  At MIT the project researching this is named, appropriately, ALIVE.[48]  Children's games are already using the beginnings of this technology to introduce students to historical figures.  To reduce artificiality , computer software makers in Japan are now producing interactive computer programs where the characters' lips are in synch with the words they speak.[49][50]

"Let's slow down and fully study this before proceeding any further."

The technologies discussed in this paper will be available and will be used, either in a well-planned manner as outlined in this paper, or in an after-the-fact reaction.  These technologies will be useful and necessary, regardless of  what mix there is between physical residency and virtual residency.  If pre-implementation studies show  there is indeed some unique aspect about the 10 1/2 months of the current resident program that cannot be simulated by the virtual residency program, the military can always retain a portion of the program as it exists today or modify it appropriately.  For instance, they can be replaced with the 2-3 week (or possibly longer) orientation TDY mentioned earlier where faculty, students, and key subject matter experts all meet each other so  the virtual representations used later will have additional meaning behind them, adding to their realism and suitability.

**Conclusion**

The proper use of emerging technology will allow us to effectively deal with the incredible increase in new information with fewer financial and personnel resources in a more demanding technological environment.  Therefore, all military personnel and organizations must be connected to the PME 2020 system.  PME institutions must be the first to change, to set the pace rather than react.  It will not be easy.

Paradigm shifts will be required. We will have to rethink what roles the computer, telecommunications, and virtual reality will have in the PME system, and what will be expected of the individual in the system.  This will consequently require a new approach to education and training.  To initiate these paradigm shifts, we must market the benefits of creating a more responsive PME system.

In the final analysis, we have four customers to convince of the relevance and suitability of the PME 2020 concept:  the PME students (individual war fighters), the students' commanders, the faculty, and the Service chiefs.  If all of the above customers cannot be convinced,  then PME 2020 will fail as have so many initiatives in the past which lacked top-to-bottom support.  Military education will then default to a reactive mode, continually behind the demands it responds to -- instead of anticipating and planning for the needs of its customers, customers who will themselves be reacting to the challenges of  a continually changing and increasingly overwhelming information and

technology environment. PME must begin to respond to the information and technology explosion, take advantage of the future characteristics of military members, boldly push forward despite fiscal constraints, and take advantage of the changing technological environment.

## Potential Technologies

### Introduction

Overall, technology is one of the two main factors necessary to meet the capability requirements of PME 2020. The other is a change in the policy and processes. While technology developments will determine the possible ways of delivering education, educational policies and processes will determine: 1) who is educated (everyone or a select few), 2) when military members are educated (at a specific time for all or at the appropriate time for each individual), and 3) where military members are educated (in-residence or through virtual residency).

Will the technology exist to support PME 2020 as envisioned in this paper? Trends in technology today, in general, indicate the necessary capability will be both available and affordable. Many of the technologies needed are already in use or under development. However, there are hurdles and resistance to overcome in successfully implementing the PME 2020 system.

### Needed technologies will be available

The technology of 2020 is not a limiting factor for implementing any ideas we have in 1994. For instance, comparing the 64K RAM computers of the early 1980's with the top-of-the-line desktop computers of today, we have witnessed an over 1000-fold increase in computer memory. This increase follows Moore's Law, a rule-of-thumb coined by one of the founders of the Intel Corporation. This rule states: the number of transistors on the main microchip in a desktop machine will double every two years. So far the rule has been remarkably accurate. [51] Since the number of transistors is a rough measure of computer power, the military can roughly predict its desktop computers in 2020 will have about 16,000 times the power of today's computers.[52] This prediction is considered a conservative estimate by many industry experts. Some predict the

computers of the next century may have billions of times more power. Some believe Moore's Law describes only the slow beginning of a curve which is becoming increasingly steep. Others believe Moore's Law doesn't take into account the coming revolutionary replacements for the transistor. These new devices will squeeze even more power onto whatever replaces the computer chip. In other words, industry experts agree, the military will have plenty of power for whatever it may dream up in 1994. Project 2851, a new standard for digital terrain, is already facilitating automatic transformation of satellite information into 3-D virtual landscapes.[53] Extensive telecommunications, virtual reality, and computer simulation for PME 2020 is assured.
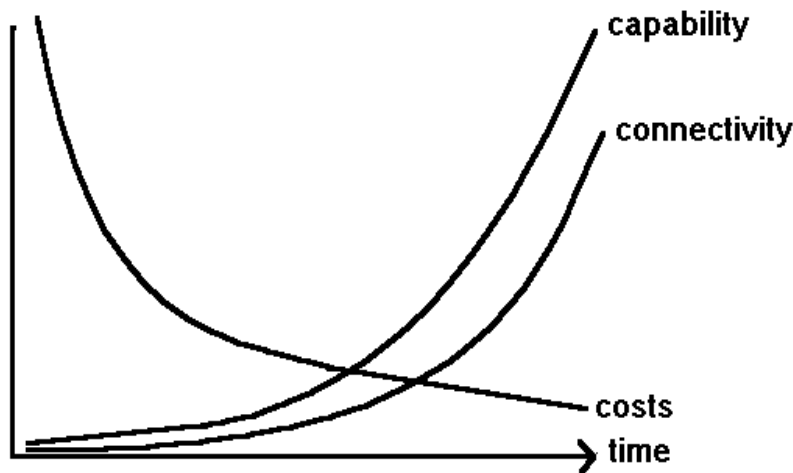
**Figure 13. Continuing Trends**

**PME 2020 Will Be Cost-Effective And Affordable**

The next question then, is whether PME 2020 will be able to afford the technology it needs to meet capability requirements. Again, analysis of today's technology cost trends predicts the future costs. Currently the price of computing capability is reported as declining between 30 and 68 percent per year. The rate cited by the ABC Evening News of 50 percent reduction every 18 months is a conservative estimate. But even using this rate, if the military wants to determine what capability it will be able to buy for each office or classroom for $5000 ('94 dollars) in 2020, it should look at the capability that $655,360,000 [54] could buy today. Imagine the technology that might be purchased in this price range for each classroom or each individual. Even if no new technologies were to develop between now and 2020 (though highly unlikely), being able to use current technology in this price range would mean a significant difference in the office, home, and school. To be able to plan effectively, the military education

system must unshackle its mind from today's limitations.  Possessing technologies in this price range will give military members greater technology on their desktop than that which currently produces all the special effects in the latest science fiction movie.  It will give each student's computer greater simulation capability than the latest simulators now used by the airlines or military, with surround picture and close-to-reality simulation.  The technologies needed for PME 2020 will definitely be affordable.

**Specific Technologies**

Today's existing technologies also provide some specific examples and insight of what is possible in 2020.  These potential technologies will solve the information, people, fiscal, and environment problems of PME 2020.  For example, potential technology exists today to solve the information overload problems of tomorrow.  Human - computer interaction devices will also aid the war fighter in this area of information management.  In addition, both virtual reality and worldwide instant access are assured.

Information Overload Solutions

As previously discussed many current military personnel already belong to wide area networks such as Internet and bulletin board services such as Compuserve.  These connectivity providers are currently developing the next generation network technologies.  This includes automated aids used to find information and people over the networks.  These automated aids are the beginnings of personally tailored automatic assistants.  PME 2020 automatic assistants will help us navigate the information highways without becoming overwhelmed.  Edify Corporation has announced their "Information Agent," which give users the ability to train computer networks to automatically gather and analyze data based on use demands.[55]  Professor Negroponte, founder of MIT's Media Laboratory, stated:  we will soon have personalized "newspapers" coming over the computer networks, with not only the news, but also the ads, aimed at the individual.[56]  Automated assistants with even greater capabilities will be used by the PME 2020 system to ensure each individual receives the most current and relevant information -- tailored to his or her needs and background.  But even with such assistants ensuring the information military people need is available, PME 2020 must teach the skills to find and use it appropriately.

Virtual reality itself is being used as a solution to the information overload. One method of employing virtual reality as a "database navigating and mining tool" is used on Wall Street for managing stock portfolios. It uses a virtual world in which stocks and groups of stocks are represented by symbols of different color, shape, position, motion, and other characteristics. This enables a stock portfolio manager to use the computer to generate patterns and color changes that summarize at a glance the health and trends of many more stocks than could be managed as well by flipping through files or complex computer screens with tables of numbers.[57] It is easy to see how this type of an application will be used to summarize much of the data that threatens to overwhelm the military person. This technology can be used by the PME 2020 system to search through the information highway and determine automatically many of the needed updates to curriculum materials.

Human-Computer Interactions Will Be Enhanced

The PME 2020 system will benefit from enhanced human-computer interaction. In 1993 these interactions already included full-body suits for gesture and other motion detection[58], computers embedded in clothing,[59] and experiments in controlling computers by thought. Regarding the latter, the Alternative Control Technology Laboratory at Wright-Patterson is making significant advances in mental (hands-off) control of flight simulators. Grant McMillan, director of the lab, stated:

> All control is brain-actuated control, as far as we know. All we're doing is measuring the output at a different point ... Twenty or thirty years from now, we might be saying, "Gee, I'd never want a pilot to control the stick with his hands when he can do it so much better by manipulating his brain activity."[60]

Military developments in hardware, software, and even "wetware (the implant of technology directly into the body)," are discussed by Manuel De Landa in his book *War in the Age of the Intelligent Machine*."[61] These upcoming technologies will ensure unprecedented realism in the virtual residency environment of PME 2020.

The military services are actively developing artificial intelligence and expert systems to aid humans to digest information and act on it. For example, expert systems have been developed for analyzing radar signatures, labeling automatically generated maps, analyzing battlefield situations and air-to-air encounters (from command level

down to helping an outnumbered pilot survive an engagement), planning for contingencies, diagnosing maintenance problems on aircraft, playing the role of intelligent opponent in war games, developing attack strategies for complex targets, helping to detect and counter C3 countermeasures, providing advice on allocation decisions, assisting launch and recovery on carriers, and even predicting likely locations and times of outbreaks of violence.[62]  Artificial intelligence and expert systems will enable PME 2020 to provide whatever information is required whenever it is needed.

Virtual Reality Will Be Commonplace



**Figure 14.  From an Ad for Virtual Reality Eyeglasses**

Nintendo is already reaching into the home with first-person virtual reality games. Already available are virtual reality eyeglasses with built-in stereo sound systems, similar in appearance to regular sunglasses.[63]  Also available is software for less than $1500 to build individualized virtual reality worlds, or a head start can be gained by buying prebuilt worlds for $90 - $400 each.  Although these inexpensive hardware and software systems don't currently match the movie studio multi-million dollar systems,  "they're sparking creative breakthroughs ... and they're helping to drive the development of an industry, a communication tool, and the ultimate multimedium."[64]

By 2020, virtual reality, or whatever its follow-on is called, will be ubiquitous. Military personnel will be used to the technology and to the capability it provides, a capability that will be a natural part of their lives -- through uses such as the Nintendo games mentioned above.  Thus, by 2020, military personnel will have virtual reality expectations -- expectations which will depreciate or reduce effectiveness of any military education which fails to use the learning interface to which the students are used to.  To avoid being placed in a reactive catch-up mode, military educational institutions must

take steps now to become proactive -- leading the way, instead of being dragged, into the next century.

> If you tell me, I'll listen.
> If you show me, I'll see.
> If I experience it, I'll learn.
>    - Lao Tse,  430 BC

> To my astonishment I was informed on leaving college that I had studied navigation! -- Why, if I had taken one turn down the harbor I should have known more about it.
>
>                            - Henry David Thoreau

The importance of virtual reality cannot be overemphasized.  The reasons for using interactive technology education are many, and evident from discussion elsewhere in this paper.  A few are listed below.

- Experiential learning.  First and foremost, interactive technology takes advantage of the strengths of this type of learning, so eloquently stated in the quotes above.

- Flexibility.  When well-constructed, interactive technology lessons allow for tailoring of lessons to the individual, the individual's learning style, and the job at hand.  Updated information can easily be dropped into the lesson and, if using a direct mode of delivery, is instantly available without waiting to deplete last year's printing.

- Timeliness.  Available on-demand.  Doable in small chunks which fit the student's schedule. Redoable and reviewable, as in remediation.  Takes up less time overall.

- Student centered.  It can be self-paced and take advantage of the student's existing knowledge -- teaching in the gaps.  It can also provide personalized immediate feedback for everything the student does or asks.

The military has already laid the foundation for the virtual reality world of the future.  For example, Navy, Marine, and Army hospitals worldwide already use an interactive video, text, sound, and graphics system for training medical personnel about combat trauma life support and preventive medicine in combat zones.[65]  The applications of virtual reality to the multimedia environment are limitless.

Virtual realities are a multimedia environment that gives users the sense of participating in realities different from their ordinary ones ... Such simulations, when done well, should provide to a user a sense of having a life-experience: learning occurs at an essential level, a fundamental change in attitudes and behavior results.[66]

The author of the above statement, Joseph Henderson of Dartmouth Medical School, also describes virtual workplaces, with virtual colleagues, whose "physical counterpart may exist in any of the far-flung problem-solving teams deployed anywhere in the world."  These virtual coworkers will meet and work in virtual hallways, virtual conference rooms, and virtual laboratories.

One can as easily imagine a virtual high school, technical school, or university, which provides access to information and expertise that is anywhere in the world.  Even difficult concepts, skills, and attitudes might be taught using vivid, three-dimensional and tactile representations of real world objects and issues.  This kind of learning environment could be embedded in the work environment (even a non-virtual one) much as today's new performance support systems provide on-line training and reference on the assembly line.  The worker need not leave his or her workplace to be trained; organizations need not establish and support fixed training facilities and travel costs can be reduced.  Learning done in direct context with work is likely to be more efficient and effective.[67]

Virtual reality, or "synthetic environments," was listed in 1992 as one of the seven main technology thrusts by the Pentagon.[68]  Victor Reis, DOD Director of Defense Research and Engineering, stated, "the demands of fighting on those battlefields [of the future], will be radically different from today's."  He also stated:  "Synthetic environments represent a technology to let us learn how to use technology better.  It's that feedback loop that does it."  Reis had recently testified:  "network simulation is a technology that elevates and strengthens the collective problem-solving abilities of ... design teams, manufacturing teams, education teams, training teams, acquisition teams, or war fighting teams."  Finally, he pointed out:  "another benefit" of the synthetic environments is "cost reduction."[69]  For all of the aforementioned reasons, virtual reality must be part of PME 2020.

Instant Access Will Be Assured

All military members will be connected to the PME 2020 system and instant access to the system will be assured. New Jersey Bell plans on having all of New Jersey completely fiber-cabled by 2010.[70] Other companies in the US and "in most industrialized nations" are planning on doing the same, or in some way providing the same level of connectivity.[71] For those areas, however remote, which will not be interlinked with cable, space will provide the same functional connection, through satellite links. Commercial enterprise will send into orbit a constellation of satellites which will enable instant contact anywhere on the globe, "a cellular system with very tall towers called satellites."[72] PME 2020 can assume worldwide two-way access to all military personnel in 2020.
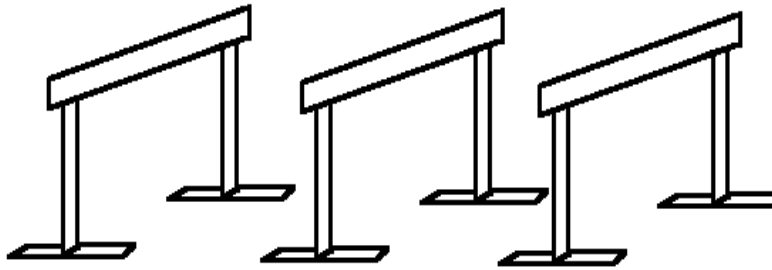
**Hurdles To Overcome**



**Figure 15. Barriers to Progress**

Hurdles to overcome include current regulations and manuals, which have yet to adapt to the rapid change of pace to which we must acculturate ourselves and the PME system. Also, due to funding limits and personnel limits, the military frequently finds itself behind in many areas of adopting the best (not necessarily newest or fastest) technologies to its needs. If the military is to progress toward a primacy of continuing career-long education through virtual residency, it must determine this now, and then develop the enabling infrastructure to channel its efforts.

Hurdles For Virtual Reality

What are the most common reasons given for not using interactive technology or for resisting its inclusion in educational programs? According to a study[73] by the Business Research Group of Newton, MA, the following were the obstacles to implementing multimedia applications:

| | |
|---|---|
| Cost | 51 percent |
| Equipment | 19 percent |
| Lack of expertise | 13 percent |
| Training | 11 percent |
| Lack of industry standards | 8 percent |
| Management resistance | 7 percent |
| Time | 6 percent |
| Inadequate applications | 3 percent |
| No obstacles | 9 percent |
| Other | 4 percent |

As previously discussed the equipment will be affordable. As the equipment becomes more user friendly, lack of expertise and training will be less significant. Industry is currently developing the standards. Therefore, resistance will be the most significant factor. Once again, promoting the advantages and applications of this technology is the only way to overcome the mind-set. For example, a survey of national business leaders and trainers, regarding what methods best improved 41 key business skills, revealed 32 of the skills were best taught using experiential exercises and/or simulations. Lecturing was judged best for one skill, listening reflectively. The remaining eight skills were judged best taught using case studies (which also could be done very easily in the virtual seminar environment). The business leaders also rated the skills in importance. The four top-rated skills (adapt to new tasks, make decisions, organize, and assess a situation quickly) were all considered best taught by simulations.[74] But even with demonstrated strengths of the methodology and technology, there will still likely be resistance on at least some level.

Resistance, Need For Champions

Del Wood, IBM design specialist, stated that among the Fortune 500 companies he has helped implement multimedia, he has frequently encountered two types of resistance. One type was due to intolerance of delayed gratification, as the users must wait for the payback on investment until after development of lessons and schedules. The other type resistance was due to "a fundamental human aversion to change," caused by multimedia lessons requiring a different set of skills, orientation, and commitment.
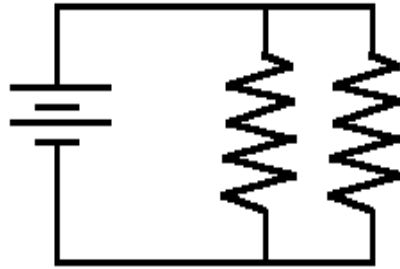
**Figure 16.  Overcoming Resistance**

Mr. Wood pointed out:  because of the diverse skills and resources needed for good interactive courseware, "it requires multiple champions and visionaries to implement a change...."[75]  This need for champions is one the military must address.  By fostering a continual, though gradual, conversion of methodologies as the military education system marches toward 2020, the system will grow the champions as the interactive system grows.

**Conclusion, Action Needs To Start Now**

The military needs to immediately establish at least a temporary home for a central repository of military and civilian research and proposed solutions regarding questions raised in this paper about potential technologies. Air University (AU) can be that initial repository.  PME 2020 recommends AU establish an on-line list of names of who is researching PME-related areas.  AU can develop this central repository and on-line capability with current technology, needing only computers, large storage devices, and on-line connectivity for incoming and outgoing information and questions.  As the military builds toward PME 2020, there will be a continual need to know what the most promising upcoming potential technologies are and how best to apply them.

# Near Term Technologies and Operational Exploitation Opportunities

"Victory smiles upon those who anticipate the changes in
the character of war, not upon those who wait to adapt
themselves after the changes occur."
- Giulio Douhet

**Introduction**

A successful PME 2020 system depends upon taking advantage of existing or emerging technology and operational exploitation opportunities.  The military must now begin planning for PME 2020.  First, an office of primary responsibility must be appointed to oversee and implement the changes.  Second, working groups must be formed to recommend changes to the PME infrastructure.  Third, emerging technologies need to be monitored constantly, watching for developments which might aid PME programs to educate military members how to effectively and efficiently manage the

coming flood of raw data.  Finally, the path to a successful PME 2020 will depend upon the quality improvement process to generate better ways to perform the education mission.  In fact, some organizations have already started to shift direction to take advantage of the near term technologies and the operational exploitation opportunities they afford.  However, the annex provides the steps that must be taken to start the military on the path to PME 2020.  To ensure a successful PME 2020, the system 2020 must initiate changes now in a planned evolutionary manner, not waiting to be overcome in a chaotic, unplanned revolution of de facto changes.

**NOW!**

If the PME system fails to plan, then the resulting unplanned implementations will hamper progress and fail to provide the education required for future military members to become the force multipliers the nation will need in 2020.  The best way to integrate new technology and processes into the PME system is to appoint a responsible office of primary responsibility (OPR) to oversee and implement these changes.  This "OPR" will also be a liaison between the PME system and civilian education systems and emphasize usability and commonalties to both worlds.  Furthermore, to meet the expected challenges and opportunities discussed in this paper, the OPR needs to initiate a restructuring of the PME infrastructure to bring it in line with the rapid changes in educational requirements.

**Infrastructure**

The PME 2020 infrastructure will be different than that of today.  The first requirement for initiating infrastructure changes is continuing to research the educational and technological environment and determine which structures will lend themselves best to rapid adaptability to technology.  PME working groups made up of various career fields, having a variety of skills and interests, need to be formed to serve as the initial catalyst for the forming of PME 2020.  They will recommend what funds are required to purchase technology.  They will develop points of contact at military and civilian institutions and both groups will share in the discovery process and act as funnels for discoveries as they happen.[76]

**Emerging Technologies**

Emerging technologies need to serve, not dictate, the development of instructional PME programs that will educate people to effectively and efficiently manage the flood of raw data.  Also, technology already exists which presents the opportunity for people to work and interact together even when geographically separated.  Taking advantage of these two technologies is absolutely essential.  Col. Jack Thorpe, special assistant for simulations at the Pentagon's Defense Advanced Research Projects Agency, stated, "We will expect a smaller military to be masters of a wider ensemble of skills.  This (interactive simulations) is an idea whose time is right."  He pointed out how using this technology drastically improved tank crews scores on real-world tests.[77]   As military resources decrease, the need for military and civilian personnel to maintain connectivity to ensure pooling of resources, whether physical or cognitive, is paramount.
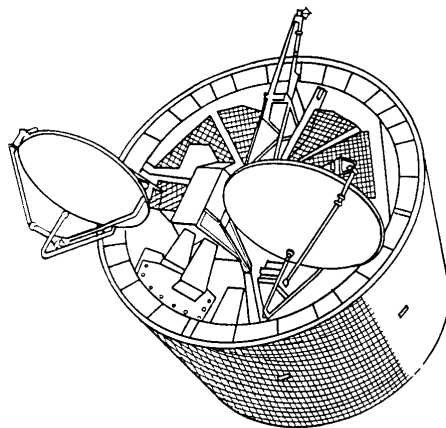
Telecommunications



**Figure 17.  The High Ground of PME 2020**

Initially, the military must employ existing telecommunication technologies in PME.  This will involve the integration of present stand-alone telephone, audio, television, computer, and satellite communication systems with interactive video capabilities and real-time access to the emerging Information Super Highway and other information-rich nodes such as the Library of Congress, colleges, and universities.  The military must also be prepared to take advantage of future technologies in this area.  By 2020, some future form of artificial intelligence technology will be part of the 2020 version of a telecommunication system.

The benefits of telecommunications will be immediate. PME's support and harnessing of integrated telecommunications will encourage individuals and groups to pursue a variety of interest areas. Personnel will be better prepared for smoother transitions between phases of one career, or between completely different careers. Comparatively speaking, this will place military personnel in a better situation than their civilian counterparts, since experts predict individuals will hold multiple careers in the future. The military organizations, as a whole, will benefit as well. If its personnel understand a few to, perhaps, several different areas, this increase in knowledge will directly contribute to, and enhance the military's flexibility to adapt to massive changes in organization, mission, and emerging technology. More importantly, this knowledge will increase the military's flexibility to adapt to any crises. Overall, people with broader backgrounds will better augment a crisis management team. Therefore, PME needs to harness the changes emerging technologies bring about. Telecommunications is just one of many emerging technologies. Human-computer interface is another.

## Human-Computer Interfaces

The PME system must begin investigating devices that aid in the "knowledge" level of information. Continual connections and computers responding to thoughts (although limited at this time)[78] are only two examples of emerging, evolutionary technologies which are allowing knowledge level information to become largely the responsibility of computers vice the responsibility of individuals. Regarding continual human-computer connection, "nearly every major computer company is currently developing wearable hardware. ... The Tender Loving Care PC for paramedics features a screen embedded in a pair of high-tech glasses and a hand-held sensor to measure the patient's vital signs."[79] These devices may not have an immediate application for the PME system, but they will have an impact on it, nevertheless. PME must train individuals to properly use these devices and manage the information they can provide.

## Quality

PME 2020 will depend heavily on the quality improvement processes. It will generate discoveries of better ways of performing the education mission. This will result in saving dollars and saving lives throughout the Department of Defense (DOD). In the Air Force Quality Institute's call for papers for their October 1994 symposium, they

include education and training programs as key elements of the "Quality Air Force in the Year 2000" sub-theme. Another major theme of the conference is "The Advanced Workplace in the Year 2000." Key elements include items directly related to the PME 2020 system: improved executive decision-making, creativity in the workplace, "personal continuous improvement (training and education)," how to facilitate change, "professional development," and the "learning organization."[80] These are all concerns of PME 2020. The quality improvement process will provide the insight required for a successful transition to PME 2020.

**Take The Lead**

Some organizations have already started to shift direction to take advantage of the new technologies. The Air War College Organizational Plan includes initiatives for a teleconferencing capability and for an interactive simulation link between the senior service schools. However, money is still needed to implement these initiatives. Also, the scope of these actions needs to be extended. The justification for the interactive, linked capability applies to personnel other than just the senior officers, and to subject matter other than just wargaming:

> Given the mandated decline of precious resources and personnel, it is in the best interest of our nation to provide our officers with every opportunity to practice in peacetime the combat decision-making they must employ in time of war. As war fighting continues to become more complex, senior leaders need experience translating national level decisions into operational action. This exercise of operational art requires not only development of plans and campaigns, but more importantly the opportunity to manage and execute those plans and campaigns. Educational wargaming provides this vitally important opportunity, and because it is process oriented, it improves war fighting, combat decision-making methodology. Compared to costly field training exercises, wargaming can provide a low-cost and certainly more efficient environment wherein officers can practice in peacetime the skills they will need in combat.[81]

## Conclusion

The April 1994 issue of *Popular Science* recalled an issue 100 years ago wherein a professor from the University of California retracted his 1888 statement that self-propelled flying machines were "impossible." Instead, he now said, "while possible, the

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engineering difficulties are enormous and possibly insurmountable." Nine years later he was proven short-sighted at Kitty Hawk.[82]  If we fail to take steps now to prepare for what technologies and processes must be developed for future education and training programs, we too will be viewed in future years as short-sighted. Unfortunately, short-sightedness in the Professional Military Education system will mean loss of lives and national power.

Our military forces will be much smaller in 2020 yet the world will be a dangerous place.  In addition, space will be added to the land, sea, and air as a conflict medium as competition among nations in space increases. This environment, coupled with the information explosion, the changing characteristics of military personnel, fiscal constraints, and significant technological advances will require a much more educated and trained force if America is to remain a military superpower in the twenty-first century.

Implementing the concepts outlined in this paper will mean taking the first steps in initiating a flexible, adaptable, up-to-date, state-of-the-art, military education and training program which is able to respond to the challenges of the world of 2020.  This paper has identified the subject and problem statement, the capability and its relevance, potential technologies, and near term technologies and operational exploitation opportunities.  All must be understood and acted upon for the US military to continue to fulfill its unique national security role in the future.  The primary method of ensuring PME 2020 is relevant to the war fighter is through the efficient and effective use of leading edge technology.  These technologies will be used to accomplish military missions, but they must also be used for PME as a force enhancer.  Colonel John A. Warden III, Commandant of the Air Command and Staff College, summarized the concept of PME 2020 best when he stated: "PME must be on the cutting edge of technology if it is to survive as an institution in the future."
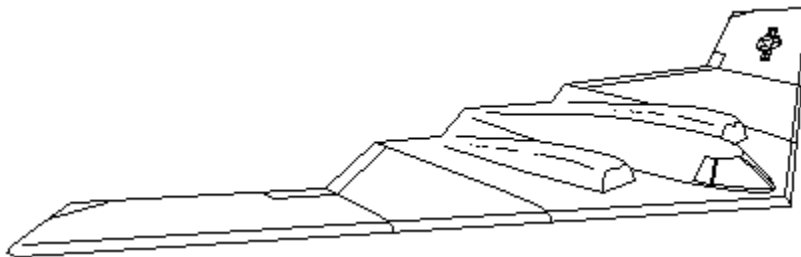


**Figure 18.  PME 2020**

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## Annex A:  Steps to Take Now

These are steps which must be undertaken immediately to start the military on the path to PME 2020:

1.  Protect the sources of future research by immediately stopping the creation of hard-copy (printed) only documents and publications at military institutions of learning and research.  At a majority of the Department of Defense schools and publishing agencies contacted by the authors, there is no current policy to even keep the disks which are used by the printers to generate books and articles.  When demand exceeds the print run, retyping and reproofing are then required. [83]

2.  Begin the process of putting all books and research papers on-line for easy access to both military and civilian researchers and for access in day-to-day operations in case the information is needed on-the-job.  But, until the access plan is developed, and the hard disks or other storage acquired (it may be as simple as putting all text on CD-ROM's), the very least the military needs to do now is to declare a halt to the routine disposal of the electronic copy of published texts.  The longer the military waits to accomplish this step, the more texts will have to be scanned or retyped in order to make them electronically accessible once more.

3.  Standardize, maintain, and enforce the skills required in the world of 2020 by immediately requiring all PME attendees to either take technology orientation courses, or "test out" of them.  If military decision makers do not understand the power of the technologies available to them, they cannot use them effectively, or even provide their fair share of ideas and innovation for making maximum use of technology.  These orientation courses will cover as a minimum the following:

> - Computer basics, such as how to copy files to and from floppies and hard
>   disks.  This will facilitate transferring projects between offices,
>   organizations, conference room projection systems, bases, classrooms,
>   and home.
>
> - Databases: what are they, how do you make them and maintain them,
>   and what can they do for your organization?
>
> - Spreadsheets and financial planning software: how do you use it to better
>   understand budgeting and procurement?

- On-line connectivity: how do you use local area networks, wide area networks, research networks, and on-line data sources?

- Presentation software and design: how do you get maximum impact in presentations, but spend minimum time designing the slides?  What are the ergonomics of good presentation.  For example, what are the best colors to persuade, screen designs to avoid, best timing and phasing of slides, and appropriate accompanying text.

- Job-specific software for particular career fields (an elective -- strongly encouraged), such as computer-assisted design software.

- Expert systems and artificial intelligence applications: what are they? Where can you find ones that will help with your field?  How do you build new ones to help with manpower shortages by multiplying the productivity of those people you do have?

- Electronic performance systems, such as interactive scheduling, personnel management, tutorials, and tailored information management aids.


4.  Re-emphasize the status of PME  institutions of higher learning by establishing them as centers for solutions to real-world problems.  Have more "think tank" type studies by military for military -- and save money as well.  Build on the experiences from SPACECAST 2020 and begin immediately to link all the education centers within the military and then link them to civilian institutions.  When military members encounter problems they will know EXACTLY who to turn to first to find the answers--Air University, NDU, or whoever is selected as central point of contact.  The PME network will  include names, organizations, and phone numbers for every type of problem military members have encountered.  New references will be added for each new problem and answer.


This is a program which could start happening immediately.  The equipment and processes used for the SPACECAST data call could be used to expand the database of resources to include these other areas of interest.  An interactive on-line forum could soon elicit the names and numbers of many other references.  During SPACECAST there was at least one prominent example of the benefit from this type approach: when two research teams within DOD discovered they were working on the same project --

"discovered" because each found out through contributing to SPACECAST that the other existed.

5. Encourage local units to develop their own PME and OJT programs by recognizing local program development for the asset it is. Civilian publications continually emphasize this "downsizing" or "rightsizing" of hardware and software technologies. The military must also maximize use of these technologies. This effort includes new development tools which allow individuals with little formal training in computers to generate their own training and management programs. This locally-initiated development is actually becoming widespread in the military as well. Today, military members are using such tools as Asymmetric Toolbook and Hyperwriter and Icon Author to develop local training and education applications. Air University and other military education centers should be taking advantage of the subject matter expertise, programming skills, and enthusiasm shown by these individuals. The following are examples to encourage this type of innovation.

- Provide military members with a forum to showcase their solutions, and possibly solve other people's problems. Examples include a central clearinghouse of programs (such as the former C2 MUG group of several years back in the Army), an on-line bulletin board for sharing solutions, or a column in the Times group (Air Force, Navy, Army, and Federal) of military newspapers.

- Provide military members with the guidance to develop the best possible education and training program. This will include a compilation of research by Armstrong Labs and others on ergonomics of screen design, equipment arrangement, and methods for interactions. It will also include guidelines on how to test students on-line, how to steer student progress through on-line lessons, and how to present lessons to maximize carryover to real-world use.

- Maximize the potential sharing of these locally developed educational and training programs. Provide guidelines on how to design applications that incorporate reusable blocks of instruction, which can easily be updated with new information and doctrine. Then provide an exchange method so military members using the same development tools can swap the procedures and routines they develop.

- Encourage innovation in educational and training by eliminating constraining requirements that, while possibly good for service-wide applications such as supply or procurement procedures, limit local initiative. The civilian sector has discovered there is no one

developmental tool which works for all problems all the time.  As the military is certainly as complex an organization as the largest of any civilian company, this same discovery lesson applies to the military as well.  For example, most computers applications include their own development "language."  Requiring all programmers to use Ada, or undertake a lengthy waiver process will discourage innovation.  Additionally, military constraints  which unnecessarily differ from civilian norms will limit the spin-on and spin-off possibilities.

- Include the best solutions to education and training problems and the names of the authors as part of the central answer database mentioned earlier.  Participation in all military efforts will improve if people feel they are receiving useful products or information from the system or are receiving acknowledgment for contributing the information to the system.

- Build on the two-way theme espoused by Gen. McPeak and others.  Require all PME participants work on solving real-world problems when they do research.  When solutions are found, direct them to the decision makers who will be able to implement them.  Highlight these solutions by submitting them to the Military Times series of newspapers.  Explain the problem and the solution and how readers can obtain copies, help, or contribute their own lessons learned and better solutions.

6.  Continue monitoring the development of the new future technologies by routinely polling leaders in the educational technology field.  Maintain the status of those technologies they believe are most important for the future, closest to development today, and those in need of the most research.  The goal is to be constantly aware of the best technologies with the greatest potential to match education solutions with on-the-job problems of the next century.  Finally, establish a military OPR for each technology.  The OPR will be responsible for answering military members' questions concerning the technology, maintaining contact with military and civilian researchers in areas directly impacting on the maturation of the technology and its application, and keeping up-to-date the on-line accessible resource list regarding that particular technology.

7.  Begin the process of connecting institutions to the PME system by establishing a direct link between all research institutions, labs or staff colleges, in the military,.  This link will serve as the means for achieving synergism between researchers, educators, and users of research results.  Flatten the information distribution pyramid.  Information must be shared at all levels between all organizations.  Information must not be "stove-piped."  As Tom Peters states in *Thriving on Chaos*:

> We must pursue fast-paced action at all costs, and therefore: (1) Vigorously and gleefully, with all hands participating, take the lead in destroying the trappings of bureaucracy. (2) Manage the organization "horizontally" - that is , insist that "vertical " obfuscating be replaced with proactive (no checking "up"), "horizontal," front-line cooperation in pursuit of fast action.[84]

8. Prepare for the classroom of the future by beginning to re-engineer it. This concepts involves more than just adding technology to the classroom. It means the military must also change the processes and methods of education.

> For 25 years ... the growth in productivity for workers surrounded by computers was dismal. The reason? Companies were trying to automate the same old paper processes. Only in the past few years, when businesses began "reengineering" fundamental activities -- opening wide swaths of their business to new approaches and reorganization -- has the technology begun to pay off.

> ...today's stultifying [education] system stems from a 20th century impulse to systematize learning and give the classroom some assembly-line-like efficiencies.

> Today the useful parallel between running a business and running a classroom may be in the way technology can empower individuals. In many corporations, advanced computer networks have given workers at all levels access to critical information. The effects can be invigorating: employees gain autonomy and take more responsibility, organizational charts flatten, and enterprises become more responsive and efficient.[85]

Remember, "resistance" will be expected from the "education establishment," especially after considering the frustration of trying to implement technologies in the classroom in the past.[86] We have to show, not just tell, today's educators the advantages of the education system of the future.

9. Incorporate the emerging technologies immediately by taking advantage of educational technology advances in the civilian community. "Indeed, the Info Highway could spur huge demand for interactive educational software."[87] Yes, it already has, as evidenced by the burgeoning selections of CD-ROM and multimedia simulations, first-person virtual realities, and interactive programs for the education market. One software catalog alone has over 550 CD-ROM titles available, many in the first-person (a

precursor to the virtual reality of the future).[88]  Among the titles are disks on Desert Storm, the CIA World Fact Book, World and US Atlases, "Twelve Roads to Gettysburg," the space shuttle,  several on space imagery, US History, cultural disks on specific countries and regions, the building of the Berlin Wall,  and numerous disks on foreign languages and science.  The information wave has begun.

10.  Begin the process of connecting individuals to the PME system by operating education and training electronic bulletin boards at Air University and corresponding locations in the other services.  All bulletin boards will be linked.  All will be accessible through both DDN (using a modem) and through Internet (for those service members who are fully networked).  Sections of the bulletin boards will include discussion areas, research areas, information "posting" areas, and sections that groups will use for specific projects and working together (the precursors of the future virtual seminars).  The interactions between military members in these sections will contribute to initial studies determining the benefits to be gained and the problems to be solved with non-collocated workers and students.  Those studies will then be used to help make the necessary decisions as the military progresses toward the methodologies, technologies, and psychology of the virtual classroom and university.

## Annex B:  Curriculum

The question is in two parts.  First, what will  the future curriculum include? Second, will multimedia and virtual reality fit into PME 2020's curriculum?

### What Will The Future Curriculum Include?

The PME 2020 curriculum spectrum is likely to include the following , in various combinations and sequences:

> Technical Training, by System and Career Field
> World History 101 - 505
> Military History 101 - 505
> Military Theory 101 - 505
> Strategy 101 - 505
> Quality Principles and Methods 101 - 505
> Space 101- 505
> Non-lethal Warfare 101 - 505
> Information Warfare, Defense and Offense 101 - 505
> Weapon Systems, Design and Use (assorted)
> Capabilities and Methods of Sea, Land, Air, and Space Forces
> Logistics and Combat Support 101 - 505
> Intelligence, Gathering and Using 101 - 505
> |Technology Update (may be repeated often)
> Group and Team Dynamics 101 - 505
> Personal Optimization, Maximizing Your Potential 101 - 505
> Creativity and Innovation 101 - 505
> OODA  Loops and Other Mental Force Multipliers 101 - 505
> World and US Political Systems 101 - 505
> International Relations and Regional Studies 101 - 505
> Culture and Its Impact on Warfare 101 - 505
> Foreign Languages (important with regional responsibilities)

### Will Multimedia And Virtual Reality Fit In It?

One of the key issues concerning educational technology was expressed well by Maureen Arnead of Berlitz International:

> Turning now to foreign language learning, will IMI (Interactive
> Multimedia Instruction) really bring about a revolution?  Will it be worth
> the effort to use the medium?  The language teacher is still suspicious --

bad experiences in the past with the much- heralded Language Lab (most of which are rusting away in some basement) had taught educators an important lesson: technology should suit educational needs and not vice versa.  Learning from past mistakes, therefore, it is critical that before any technology be adopted, the conditions for a successful language learning environment must first be determined.  In order to make a responsible decision about the use of multimedia courses in the classroom, it is critical to differentiate between multimedia technology -- the hardware and software -- and the educational principles underlying use of this technology so that suitability for students, curriculum and presentation style can be determined.  It goes without saying that these principles should dictate which educational tools are selected and not vice versa.[89]

To successfully incorporate  interactive multimedia and virtual reality  into the curriculum, PME 2020 must emphasize their evident benefits.  For example:

- Learning is experiential.  You try before you fly.

- Saves money and time.  You practice on recyclable electrons, not expensive nonreuseable resources.  Training examples in and out of the military have already exhibited increased retention, reduced costs, and reduced time.

- Recognizes individual differences.  Individuals find details and explanations a mouse-click or virtual eyeblink away, thus leveling the playing field to take into account the variety of backgrounds students bring to the "classroom."

Notes

1 Gen Merrill A. McPeak, "The Key to Modern Airpower", *Air Force,* September 1993, 46.

2 "Quest for Quality '94", Air Force Quality Institute, Quality Air Force Symposium, call for papers, to be held 11-14 Oct 1994.

3 Alvin and Heidi Toffler, *War and Anti-War* (Boston, Mass.: Little, Brown, and Co., 1993), 73-77.

4 Garrett Culhane, "Mission to Planet Earth", *Wired*, December 1993, 94-97.

5 CNN, "Future Watch", 27 March 1994.

6 Culhane, 94.

7 Ibid., 96

8 McPeak, 43-46.

9 Writing in, *Technical Horizons in Education Journal*, Lee Droegemueller, Kansas Commissioner of Education, gives one view of the education world of the next century:

> ... visible transformations in the world of work indicate the future integration of the workplace, home, and school. Responsibilities, functions, and activities that once occurred exclusively within each domain are crossing over into other environments. ... No longer can the school, the office, and the home be separate from one another. These three once-distinct entities are breaking apart, combining and overlapping in new ways.
>
> The major connector of these three entities -- home, school, and work -- is technology ... Thus the direction for planning must be to build the learning community and to focus upon connectivity. This means that the communication systems, networks or infrastructure among the community partners, and how they are connected to the world, become the top priority.

To avoid a similar fate (to businesses which were overwhelmed by technology), schools must use technology for students to learn. Technologically connecting the school with the home and work will make learning relevant and useful. Learning will have no boundaries, as students can connect with others to access information, ideas and experiences from within the community, across the state and around the world.

10 Lee Droegemueller, "Connecting With the Future Today," *Technical Horizons in Education Journal*, April 1994, 10,

11 SPACECAST assumptions.

12 McPeak, 44.

13 Toffler, 158.

14 Toffler, 158.

15 McPeak, 44.

16 Currently, the military has already started new recruitment strategies in over 50 career fields. These strategies are aimed at recruiting individuals who already possess the basic skills needed for various specialties. These individuals require little if any training in the basics of their career field.[16] The attractiveness of PME 2020 technologies will enhance this strategy. PME 2020 will not only help recruit these targeted individuals, these same technologies will help retain them.

17 Policy Letter from the Secretary of the Air Force, September 1993, 4.

18 In a survey referenced in CIO magazine, the importance of various factors in attracting and retaining technology related professionals were rated by those professionals. The opportunity to work with leading-edge equipment was rated as very important by 64 percent of those surveyed, opportunity to work on important projects -- 62 percent, enthusiasm for the mission of the business -- 57 percent, and opportunities for promotion into management received only 36 percent

19 Joseph P. Shapiro, "Just Fix It", *U.S. News,* 22 February 1993, 50-54.

20 Philpott, 10.

21 Shapiro, 53.

22 McPeak, 44.

[23] Alvin Toffler interview with Peter Schwartz, "Shock Wave (Anti) Warrior", *Wired*, November 1993, 121.

[24] James Kitfield, "Schooled in Warfare", *Government Executive,* October 1991, 22-27.

[25] Tom Peters, *Thriving on Chaos* (Harper Perennial, 1991), 386.

[26] Bruce Sterling, "War in Virtual Hell, *Wired*, Premier Issue 1993,99

[27] Larry Armstrong, Dori Jones, and Alice Cuneo, "The Learning Revolution", *Business Week,* 28 February 1994, 80-85.

[28] Del Wood, "Instructional Technology in the Business Environment", Interactive Multimedia '93 Proceedings, 25-27 August 1993, 52.

[29] Caterpillar used interactive media for language training and saw 50-60 percent savings, and expects to save up to $20 million in US operations alone. Bethlehem Steel uses over 100 interactive courses, including more than 15 as part of their Total Quality Management (TQM) program, and reports 20-40 percent time savings, higher retention, and increased participation in voluntary programs. Ford Motor Credit Company estimates cost savings of 25 percent. Bell South reports one program saved $5 million and 20,000 days of instruction. They also have condensed a five day conventional course into a seven hour interactive course. They report an 80 percent time savings with 40 percent higher retention levels. Ibid., 56.

[30] Ibid., 57.

[31] Kitfield, 24.

[32] Clarence A. Robinson, Jr, "Powerful Nomadic Devices Offer Global Network Access," *Signal* (official publication of AFCEA, March 1994, 23.

[33] News item, "Science and Technology Week," CNN, 2 April 1994.

[34] Jaques Leslie, "Connecting Kids", *Wired*, November 1993, 90.

[35] Jacque Leslie, "Mail Bonding," *Wired*, March 1994, 46.

[36] Ibid., 46.

[37] Gen McPeak, Policy Letter.

[38] For example, the multimedia lessons Air Command and Staff College is integrating into current curriculum may have value at civilian institutions or on the commercial market as well. These or other military-created products could be sold or traded for information or services. As the military develops expertise in authoring in the virtual reality and simulation areas, there no doubt will be opportunities to sell actual or modified products to civilians, or encourage commercial vendors to develop items the military requires, by providing a less risky, guaranteed, military market.

[39] Toffler, *War and Anti-War*, 147.

[40] Current international students have mentioned to Air War College faculty (including one of the authors) after seeing the abilities of the US military, they "are sure glad we don't have to fight you." The open nature of PME 2020 should spread this view on a much greater scale

[41] G. Ronald Christopher and Robert R. Bergseth, "Meeting Air Force Educational Requirements Through Media", Orlando Multimedia '93 Conference Proceedings, 24-26 February 1993, 68-70.

[42] Philpott, 10.

[43] Ibid., 10.

[44] Toffler, *Wired,* 121.

[45] Audrey Merwin, "Videoconferencing Goes to Work," *New Media*, November 1993, 64.

[46] Richard Lipkin, "A Face by Any Other Name", *Science News*, 2 April 1994, 216.

[47] Sterling, 51.

[48] Lipkin, 220.

[49] News Item, "Make Sense of Japanese with Your Own Sensei", *Windows* Magazine, May 1994, 90.

[50] A recent CNN news tidbit featured a computer-generated virtual Mark Twain for rent. This Mark Twain responds to almost any question with a witty response that takes into account all of Twain's writings and biographical notes from people who knew him. He's currently being used primarily for promotional events at shopping malls, but he definitely shows the potential for PME 2020 to introduce historical figures and experts into the classroom.

[51]. Kenneth M. Sheldon, "Micro 2000", *Byte*, April 1991, 132.

[52] 26 years divided by 2 = 13. $2^{13}$ = 16,384

[53] Sterling, 98.

[54] 18 months goes into 26 years slightly more than 17 times. Working backwards from 2020 yields $5000 times 2 to the 17th, which equals $655,360,000.

[55] "Special Deliverer", CIO, 1 June 1992, 71.

[56] Bob Metcalfe, "Get Ready for Personalized Newspapers", *InfoWorld*, 5 April 1993, 52.

[57] Sara Hedberg, "VR Art Show at the Guggenheim", *Virtual Reality*, Premier Issue 1994, 73.

[58] News item, *Wired*, April 1994, 38.

[59] A. J. S. Rayl, "Dress Code: The Ultimate PCs Will Be Worn," *Omni*, December 1992, 20.

[60] Bennett Daviss, "Brain Powered," *Discover*, May 1994, 60.

[61] Gareth Branwyn, reviewer, "The Machines Take Over: War in the Age of the Intelligent Machine", *Wired*, Premier Issue 1993, 84.

[62] Donald A. Waterman, *A Guide to Expert Systems*, (Reading, Mass.,: Addison-Wesley, 1986) 289-293.

[63] Advertisement by RPI Advanced Technology Group, in *Virtual Reality*, Premier Issue 1994, 65

[64] Linda Jacobsen, "Homebrew VR", *Wired,* Premier Issue 1993, 84.

[65] Joseph V. Henderson, MD, Dartmouth Medical School, "Virtual Realities as Instructional Technology", Proceedings of S.A.L.T. Interactive Instruction Delivery Conference, 20-22 February 1991, 121-125.

[66] Ibid., 121.

[67] Ibid., 125.

[68] Brian Green, "Technology on Five Fronts", *Air Force* Magazine, September 1992, 62-66.

[69] Ibid., 62-66.

[70] Robin Nelson, "Swept Away by the Digital Age," *Popular Science*, November 1993, 107.

[71] Ibid., 93.

[72] Joe Flower, "Iridium", *Wired*, November 1993, 72.

[73] "Interactive '94" Conference Announcement.

[74] Richard Teach, "What Do We Teach When We Use Games ?", *The Simulation and Gaming Yearbook,* 1993, 112-121.

[75] Del Wood, *Instructional Technology*, 51-58.

[76] The working groups will formulate positions on numerous educational related subjects. Questions such as: 1) what are the true benefits of resident programs versus nonresident ones, 2) when will virtual residency be advanced enough to replace resident programs, and 3) what taxonomy, if any, should replace Bloom's will need to answered when the military begins to incorporate emerging technologies into the PME system.

[77] Col Jack Thorpe, *Business Week*, 5 October 1992, 96-100.

[78] Bennett Daviss, 60.

[79] A.J.S.Rayl, 20.

[80] Air Force Quality Symposium, *Quest for Quality '94*.

[81] Air War College Organizational Plan, 1 June 1994, Initiatives B93AWCTE-05 and B93AWCTE-04.

[82] Candace Golanski, "Looking Back", *Popular Science*, April 1994, 116.

[83] When one of the authors asked an organization about obtaining a copy of a very popular book they had produced, he was informed they did not have enough copies left to freely give them out anymore. Additionally, the organization would have to retype the entire book if they wanted to print more, since neither they nor the printer had kept the floppy disk copy of the text. Ironically, the organizational representative said she thought the disk had been reused to save the cost of buying a new floppy disk. That floppy disk cost 40 cents. Compare that cost to the cost incurred by not keeping it with text intact.

[84] Peters, 554.

[85] John W. Verity, "The Next Step: Reengineering the Classroom", *Business Week*, 28 February 1994, 88.

[86] Armstrong, Jones, Cuneo, 82.

[87] Ibid., 85

[88] *EDUCORP CD-ROM Title Wave Catalog*, Spring 1994.

[89] Maureen Arneaud, "The Potential Impact of Multimedia", Interactive Multimedia '93 Proceedings, 25-27 August 1993, 71.