Technology Support for Distributed Learning at NPS:

A Story of System Evolution

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Abstract

This paper describes the history of distributed learning (DL) at the Naval Postgraduate School (NPS), focusing on the technologies that were implemented and adapted for learner and instructor support. A description of distributed learning in North America in the latter half of the 20^{th} century sets the context for the efforts at NPS. The challenges and successes of early adopters are described. Available technologies and how they were adapted for educational purposes are described. The co-evolution of learning strategies and supporting technologies is discussed. Champions and opponents of DL are discussed, along with how they identified or aligned themselves. The current state of DL technology and institutional support is provided. Finally, the paper presents several continuing and emerging challenges that appear to limit the growth of DL technology along with an assessment of several mechanisms which offer potential solutions.

Introduction & Background

Distance education appears to have come into being only recently with the broad adoption of electronic communications and computer technologies available in the latter decades of the 20th century and early in the 21st. However, if we take the more general definition of distance learning (DL) to be that "educational technology encompasses any means of communicating with learners other than through direct, face-to-face, or personal contact" [Bates & Poole, 2003], our story of distance education systems evolution will be more complete. A history of a technology domain should include an appreciation for predecessor systems. If the past is a prologue, then it follows that a history of a technology domain is necessary to understand technological change: this paper presents predecessor systems related to DL instruction in order to present a continuum of technological change. As Larreamendy-Joerns & Leinhardt [2006] say, "the history of distance education constitutes not only a repository of experiences with heuristic value but also the frame within which the community of educators" may come to an understanding of distance education.

If we allow that distance education is any formal education in which the learner and instructor are separated physically, then the history of distance education could be traced to the early 1700s in the form of correspondence education [Jeffries, 2011; Garrison, 1985]. (The problems in defining distance education itself as discussed by Keegan [1988; 1996], by Garrison and Shale [1987], and by Moore and Anderson [2003] are not included here.) Correspondence education was sometimes referred to as 'correspondence study' or 'home study' or 'external studies' [Keegan, 1996]. In the United States, the first correspondence course was offered by the Phonographic Institute in Cincinnati, OH, in 1852 [Casey, 2008]. Several correspondence-only organizations were established in the 1870s and 1880s, including the Society to Encourage Studies at home founded in 1873 to provide women with a liberal education and the International Correspondence School for miners and railroad workers [Larreamendy-Joerns & Leinhardt, 2006; Casey, 2008]. The first recognized academic institution to offer a college-level correspondence program was the University of Chicago in 1892 [Larreamendy-Joerns & Leinhardt, 2006; Casey, 2008; Lease & Brown, 2009]. Interestingly, the founder of the University of Chicago's program used phrases like "our classroom can be world-wide" and "our constituency embraces . . . representatives of most of the professions and vocations" [Larreamendy-Joerns & Leinhardt, 2006]. While clearly intended to reflect the purpose of his outreach via courses-by-mail, it is a prophetic statement applicable to most on-line courses today. Other early adopters include the University of Wisconsin with a program as early as 1891 [Larreamendy-Joerns & Leinhardt, 2006]. All correspondence teaching has been labeled "first generation" distance learning [Garrison, 1985; Nipper, 1989]. The primary medium was written or printed material. Students received course syllabi and texts, and submitted lessons and other material in the mail [Lease & Brown, 2009].

To us, early correspondence courses may appear quaint. However, they are the progenitors of what we call distance learning today. Those correspondence courses in the 19th and early in the 20th century were themselves supported by the technology available in their day. Garrison [1985] called this the first generation of distance education technology: "combining the printed word and the postal system as a medium of two-way communication." Steam powered locomotives enabled mail to be carried by rail, at speeds and reliability much greater than those of animal- or human-powered conveyances. The speed of the correspondence meant the time between an instructor asking a student to submit work and then receiving that assignment was measured in days, not weeks or months. Assessments could be made and the feedback returned to the student, also within days. Thus, DL's technological evolution traces back to the time of the so-called Industrial Revolution. They provide the first "crucial artifactual antecedents" necessary in illustrating a continuum of invention [Basalla, 1988]. Their strengths of freedom in choosing when and where to study and broad reach are some of the characteristics of early distance learning programs which have been carried forward into later generations. Of note for this analysis is the fact that the weakness of these programs - their slow and ponderous interaction rate - has been addressed by the next generation [Garrison, 1985]. It is the level of interaction that can take place between student and teacher, and between students themselves, that is the core problem addressed by DL technology.

Radio broadcasting in the 1920s was the next step in technological evolution. The first educational radio licenses were granted to the University of Salt Lake City, the University of Wisconsin and the University of Minnesota; over 200 such licenses were granted between 1918 and 1946 [Casey, 2008]. Live educational programming "reduced instructional delivery time and increased classroom immediacy by allowing distant students to hear their instructor" [Casey, 2008]. However, there was only one college-level credit course offered by radio in 1940 [Casey, 2008]. Following WWII, American soldiers discovered some German radio stations were automated, operating without personnel. The Germans had developed audio recording tape which meant that educational materials like lectures could be recorded easily. This led to the development of correspondence courses that were printed, as usual, but which were also supplemented with audio recordings [Lease & Brown, 2009].

Having considered radio, the next communications electronics technological advance is television. This medium was first used for instruction by the University of Iowa in 1950 [Lease & Brown, 2009]. (There is some conflict on this date; Casey [2008] documents1934.) By 1963, the FCC established a band of 20 television channels to provide educational institutions a "low-cost, fixed-range, subscriber-based system capable of being utilized for the distribution of broadcast courses" [Casey, 2008]. Distance learning began appearing in more schools, both in the United States and around the world. Additionally, some discipline in establishing and monitoring course quality was brought to the practice of education via these media. The University of Wisconsin established an Articulated Instructional Media project in 1964 intended to offer direction on the creation and incorporation of multimedia instructional packages [Casey, 2008]. This is the first establishment of institutional support for faculty developing and delivering mixed-media courses. The federal government made a commitment to distance learning by establishing the Corporation for Public Broadcasting in 1967. This organization became the Public Broadcasting Service in 2003 [Casey, 2008] and continues to provide educational programming for learners of all ages. (It should be noted the author learned about reading and the alphabet via PBS programs like Sesame Street and The Electric Company as a child, and just last month, learned what Ötzi, a 5,000-year-old mummified iceman, had for his last meal.) In 1970, Coastline Community College in Orange County, CA, offered the first fully televised college course [Casey, 2008]. In 1972, other colleges in California, Florida and Texas also had televised course offerings. This is the so-called "second generation" distance education which may be called multi-media distance teaching. The use of print was integrated with broadcast media and video or audio recordings [Garrison, 1985; Nipper, 1989].

The drawback of broadcast radio and of television for education is its inherent one-way nature. The two-way interaction between student and instructor was not supported. Even ambitious efforts like the National Technological University (established in 1982) with 40 member institutions connected via satellite for program transmission were limited in this lack of "live" interaction between student and instructor. Students had to use telephones to interact with instructors during class [Casey, 2008]. Because there was no interactivity, the social processes of learning were not enabled [Nipper, 1989]. This is where the story of technology evolution in support of DL diverges somewhat. More precisely, different communication technologies evolved in parallel, driven by the availability of the technology and its efficacy in meeting the needs of distance learners and educators.

The lowly telephone, in existence since the 1870s, was not widely used for education until the late 1980s when teleconferencing technology enabled many-to-many audio conferences. One instructor could "meet" with several distributed students and even invite guest lecturers from remote locations [Lease & Brown, 2009]. "The use of audio teleconferencing marked a significant innovation in the delivery of distance education . . . the agonizingly slow interaction of correspondence study was overcome" [Garrison, 1985]. If broadcast television is the child of broadcast radio, then video-conferencing is the child of audio teleconferencing. Video-conferencing was demonstrated at the World's Fair in 1964, with AT&T introducing the Picturephone in 1970, and Nippon Telegraph and Telephone establishing video-conferencing between Tokyo and Osaka in 1976 [Nefsis, 2011; Roberts, 2004]. These systems were unique to their parent corporations and were not offered for sale. Compression Labs introduced their VC system for sale in 1982 for $250,000 with lines for $1000 per hour [Roberts, 2004]. PictureTel introduced their first commercial video-conferencing product in 1986, and it was significantly less expensive at only $80,000 with $100 per hour lines [Roberts, 2004]. It did not really become cost-effective until 1992 [Nefsis, 2011]. Video-conferencing became widespread in the mid-1990s mostly in the business world because, even though expensive for an initial purchase, it was less costly than travel. Video-conferencing proved to be a boon to distance education, with many higher education institutions adopting it for course delivery in the mid-1990s and 60% still use it [Lease & Brown, 2009]. Video-conferencing systems are based on a codec (coder/decoder) that encodes and compresses analog audio and video signals then transmits and receives signals via commercial ISDN (Integrated Services Digital Network) lines [Owen, 2003; Koczela & Walsh, 1996]. Technical standards for compression and packetizing developed in parallel with commercial codec development. The International Telecommunications Union issued the first version of the H.320 standards in 1990 for the overall structure of control and data signals and H.263 in 1996 for reduced bandwidth transmission [Roberts, 2004]. It is now nearly as easy to initiate a video-conference as it is to dial a telephone.

Computer networks were another way to overcome the drawback of one-way interaction between instructor and students. A complete history of the digital computer and the Internet is beyond the scope of this paper. We will just mention the first email was sent in 1978 (via Intel's internal network) and the first computer conference to support DL was introduced at the Jutland Open University in 1982 [Nipper, 1989]. The use of internetworked computing is part of the "third generation" of distance education [Garrison, 1985]. By 1989, University of Phoenix was founded on the concept of offering only computer-supported DL programs [Casey, 2008]. In 1991, instruction was widely available through the World Wide Web via the online course management system Blackboard [Casey, 2008]. Commercial products enabling IP-based video-conferencing including PicTel for the PC (introduced in 1991) and CU-SeeMe for the Macintosh (1992) [Nefsis, 2011; Roberts, 2004] have enhanced student-instructor interaction over the web. In 1993, Jones International University in Colorado became the first fully online university to be accredited by the Higher Learning Commission [Casey, 2008]. In 1995, there were over 250,000 students enrolled in such programs at seventy institutions in the United States and some estimated 30 million students worldwide [Keegan, 1996]. For the first time, more students enrolled in DL courses than entered all U.S. colleges and universities as freshmen [Wisher *et al*, 1999]. Owen [2003] recognized that web-based education would become a great boon to DL, providing an opportunity for any student unable to attend resident classes with an opportunity to earn a degree. By 2011, nearly 4.3 million non-resident undergraduate students were enrolled in postsecondary institutions in the United States alone [NCES, 2011]. There are now many online course management systems, including not just Blackboard, but Moodle, SharePoint, Fronter, Joomla, Halogen, Sakai and more than the author cares to list. Web-based video-conferencing support tools include Oovoo, WebEx, GoToMeeting, WebMeeting, Adobe Connect, Elluminate and many others that have the capability to support DL. From the preceding lists of available technologies, one could say we are in the golden age of “third generation” distance education in which the immediacy of interaction between learners and instructors is supported by a broad array of telecommunication and computer technology.

Effects of Technology on Education and Learning

Distance learning has flourished in the United States because of the distances between people and institutions of higher learning, a thirst for education, and because of the rapid advancement of technology [Casey, 2008]. The concept of “distance” relates not just to geographic space but also to socio-economic differences. A common theme behind initiation of online programs is “democratization or the intention of increasing either the access to higher education of populations that would otherwise be excluded, or increasing the range of people who might be served by elite institutions” [Larreamendy-Joerns & Leinhardt, 2006]. A common approach has been for traditional universities to adapt existing programs for DL and online delivery. (The author notes that DL and online education are not necessarily the same things, but the ubiquity of the Internet precludes discussion of one without the other.) Examples include Columbia University, Yale University, Stanford University, Massachusetts Institute of Technology, Carnegie Mellon University [Larreamendy-Joerns & Leinhardt, 2006], and the University of Chicago (already mentioned as the earliest adopter of correspondence programs). The primary driver for early 21st century explosion in enrollments is the development of a range of technologies for communications from the mid-1980s to the mid-1990s [Keegan, 1996; Casey, 2008]. The electronics technology includes “universal mobile telephony, satellite virtual classrooms, universal personal telephony, fibre-to-the-local-loop, two-way video codec systems, video-conferencing to the desktop, broadband ISDN, the Internet, and multimedia to the home” [Keegan, 1996]. The Internet has taken distance learning from the periphery of university life to its center and universities “attempt to seize the online market with the expectation of expanding their reach, increasing revenues, and recovering some of the investments they have made in technology” [Larreamendy-Joerns & Leinhardt, 2006]. Development of online programs have become indicators that institutions are “up-to-date and on the cutting edge of educational strategies” [Larreamendy-Joerns & Leinhardt, 2006]. So our system evolution reflects trends observed in other domains and technology in general: a co-evolution of technology and its business or professional environment. Intermediate forms exist that connect the past with the present. Garrison [1985] also recognized this trend: “a hierarchical structure with an increasing differentiation of technological capacity.” There is a natural cycle of the origination of a new principle, followed by growth and development, through deepening and elaboration to overcome limitations. The surrounding structure and professions adapt and then make new demands. The changes in technology and its supported domain are so closely intertwined, it is like the organic co-adaptation of plants and animals in an ecosystem. We must be careful to not let the Darwinian analogy carry us too far. Technology changes not of its own volition, but through design decisions of technologists.

Criticisms of DL, Old and New

Just like any industry, in the domain of higher education, there is resistance to any new technology. It "creates a cognitive dissonance, an emotional mismatch, between the potential of the new and the security of the old" [Arthur, 2009]. "New technology is often seen as a threat to tradition and to the control of the academic profession over the process of learning" [Bates & Poole, 2003]. Keegan [1996] recounts how the opening of the Open University of the United Kingdom in 1970 was met with hostility and skepticism. (Today, this university continues a "vigorous tradition of more than a hundred years of distance education" [Larreamendy-Joerns & Leinhardt, 2006], providing 21% of all higher education in the UK [Casey, 2008] and is ranked by official government agencies among the top ten British universities [Bates & Poole, 2003].) Continuing our biologic-evolution metaphor, online education has inherited all the concerns voiced about its ancestor, correspondence-based distance education. These concerns range "from faculty reticence about instructional quality to the perils of pedagogical imperialism" [Larreamendy-Joerns & Leinhardt, 2006]. Criticism of distance education started with criticism of those early outreach programs at the University of Chicago and the University of Wisconsin. The perspective of the university as an elite institution, serving an elite student community is reflected in economist Thorstein Veblen's 1918 critique of correspondence study as "frills – no more appropriate to higher education than football and fraternities" [Larreamendy-Joerns & Leinhardt, 2006]. Also mirroring today's criticism of online programs, those correspondence programs overpromised their own potential and were unable to sustain their momentum because of the absence of organizational infrastructure. There was no incentive for faculty to invest themselves in the new mode of delivery. They deemed their teaching load through correspondence oppressively time consuming. In fact, lack of institutionalized support almost resulted in the cancellation of the University of Chicago's correspondence program [Larreamendy-Joerns & Leinhardt, 2006]. Sound financial support was also lacking, "leading administrators to advertise services and to search for students through solicitors" [Larreamendy-Joerns & Leinhardt, 2006]. Those students also did not have an opportunity to interact with each other, studying mostly at home, on their own. Communication among learners was non-existent [Nipper, 1989]. There was no community for learning. Another early critique that we still sometimes hear today asserted that distance programs provided training but not education. Education is "broad, deep, and philosophically anchored to a sense of purpose and general utility . . . necessary to the making of a free human being" [Larreamendy-Joerns & Leinhardt, 2006]. Training is more closely associated with learning a specific task or a particular vocation. DL can support either goal [Wisher *et al*, 1999; 2000].

The oldest criticism having received the most attention revolves around instructional quality. Since the inception of correspondence courses, advocates of distance education have been asked to show that distance teaching and learning were as good as those of resident programs. The founder of the University of Chicago's program studied the issue himself. He discovered the disadvantages of correspondence to be "lack of the instructor's personal magnetism, the absence of classroom interaction . . . and increased opportunities for dishonesty on the student's part" [Larreamendy-Joerns & Leinhardt, 2006]. However, he was quick to debunk myths asserting the superiority of resident instruction: "If personal stimulus furnished by the teacher is absolutely necessary to good results on the part of the student, then two-thirds of the oral instruction given is valueless" [Larreamendy-Joerns & Leinhardt, 2006]. More formal empirical studies comparing distance education to traditional resident education began early in the last century with the seminal work by Bittner and Mallory "University Teaching by Mail" published in 1933 that asserted "correspondence students do make good by arbitrary standards commonly employed to measure achievement" [Larreamendy-Joerns & Leinhardt, 2006]. In today's world, the assertion that there is "no significant difference between online and VTE-enabled distance learning and face-to-face learning" has been made many times. A complete discussion on the effectiveness of DL is beyond the scope of this paper. The author found no fewer than 100 such studies in the last year. In general, "current literature on distance learning that suggests there is no significant difference between the effectiveness of distance education and traditional resident education" [Roberts & Owen, 2009]. In the author's experience, the effectiveness of a course is determined more by the course design effectively tailored for a delivery mode rather than the delivery mode itself. This topic will be treated in more depth shortly.

There is another factor associated with introduction of modern technology to support distance education. Like the workers in 1800s England, responding to the introduction of power looms and spinning frames by smashing the new machines, we students and educators are also threatened. More than one educator has refused to allow the recording of his lecture and has refused to share electronic versions of his course material, claiming "if they have my lecture, they won't need me." Those fears are unfounded. Professors write books and articles, which are their thoughts and work recorded in a print medium. Video recordings just capture the same thing in a different form. However, it is recognized that gaffes are recorded; like publishing the first draft of a paper, mistakes and all! Further, just like old books and articles, old recordings become stale after a short time. There is no threat to job security. What I want to address is more than just jobs or employment. It reflects the fears of those Victorian textile workers and Luddites. We may become so enamored with our technology and it may become so pervasive that we become slaves to the machine. We teach and learn to its rhythm, not our own natural pace. This is not a trivial concern. Several authors have levied the critique that compliance to the form of an online course management system forces bad pedagogy [Payne, 2005] and technology-driven thinking leads to overly-constrained instructional design [Burge, 2008]. An extreme perspective is offered by Sumner [2000] who contends the tools available to distance educators have become the instruments of "the system" of corporate globalization subjugating the "lifeworld" of culture and social integration. "In this information age, distance education exists within a larger context . . . in which powerful, interconnected, stateless corporations nullify national boundaries and incorporate whole societies as cost-effective sites of production . . . distance education becomes a business opportunity" [Sumner, 2000]. Theories of global corporate conspiracies and accusations of intellectual neo-colonialism aside, there is a trend toward "commoditization" of distance learning materials, a mass-production of objects for sale.

That speaks to our understanding of teaching and learning itself. One analogy for learning is "the instructor pours liquid from his pitcher into the student's glass and then the student pours it back out without spilling a drop." However, higher education should seek a more mature model in which the students "fill their own glass" using the raw ingredients provided by an instructor and his course material, and then they "pour their own liquid" when and where necessary. Students are empowered and enabled to apply new knowledge to solve problems on their own. The differences between a behavioral learning theory and a cognitive constructivist learning theory in the online environment are described by Garrison [1993]. Advancing the intellectual maturity and critical thinking abilities are worthy goals of higher education. "All in all, authoritarian, one-way, top–down, content-driven coursework does not promote the cognitive development that is the hallmark of higher education" [Sumner, 2000]. So, then, we should not allow ourselves to be slaves to our own creation, but change our role as educators, seeking learner-centered activities, encouraging "interaction with content and interaction with other people," and becoming facilitators in a constructivist model [O'Neil, 2006; Wisher *et al*, 2000]. In the online environment, we can design courses in which "intellectual acquisition replaces the didactic force of the teacher as the main impetus of learning" [O'Neil, 2006]. We can use the technology to "set and achieve personal learning goals such that learners take responsibility to construct meaning and not just simply extract answers for prescribed questions" [Garrison, 1993]. The author has used the terms "distance education" and "distance learning" almost interchangeably. However, the learner-centered approach, which emphasizes transfer of knowledge via constructivist practice and students' responsibility for their own education, suggests we differentiate the two and use "distance learning." The point of this excursion into constructivism is that adapting one's pedagogy to the times is necessary, but that does not necessitate abandoning our basic theories to adapt to new delivery modes. We should seek a harmonious, interactive, and two-way relationship to technology; to not lose our heads to its power or newness, or become crippled by the means it gives us to teach.

Distributed Learning at NPS – The Beginnings

In 1909, Secretary of the Navy George von L. Meyer established a school of marine engineering at Annapolis under the direction of the Naval Academy superintendent. In 1912, the name was changed to the Postgraduate Department of the Naval Academy and to Naval Postgraduate School in 1919 [NPS Factbook, 2010]. The only curricula were in mechanical engineering, electrical engineering, ordnance, naval construction, and civil engineering [Post Graduate Department, 1915]. Courses also included a "Shop Practice Option" and a "Design Option" for mechanical engineering and "Radio Engineering" for electrical engineers, which were taught at Columbia University [Post Graduate Department, 1915]. Similarly, courses in naval construction were taught at Massachusetts Institute of Technology and courses in civil engineering were offered at Rensselaer Polytechnic Institute [Post Graduate Department, 1915]. In 1945, Congress passed legislation establishing the Naval Postgraduate School, "the primary function of which is to provide advanced instruction and professional and technical education and research opportunities for commissioned officers of the naval service" [U.S. Code, 1945]. The school moved from Annapolis to Monterey, CA, in 1951. The mission of NPS is now to "enhance the combat effectiveness of the Navy and Marine Corps by conducting and directing advanced education of commissioned officers, and provide such other technical and professional instruction as may be prescribed to meet the needs of the Naval Service . . . to sustain academic excellence, foster and encourage a program of relevant and meritorious research" [OPNAV INST 5450.210C]. Today, NPS has grown from a technically-oriented institution with only engineering courses to serve the broader and changing needs of the Joint services with stabilization and reconstruction along with homeland defense [NPS Factbook, 2010]. The school has over 40 programs of study including electrical and computer engineering, mechanical and aeronautical engineering, systems engineering, space systems and satellite engineering, physics, oceanography, meteorology, applied mathematics, computer science, operations research, business and public policy, international relations, and other disciplines, all with an emphasis on military applications [NPS Factbook, 2010]. Most programs grant degrees of MS or MA, with several PhD programs and a few shorter "certificate" programs composed of a 3- or 4-course sequence. NPS is the nation's research university for the Department of Defense.

Like other colleges and universities, the Naval Postgraduate School started with programs based on correspondence courses. Course catalogs from NPS encouraged incoming students to request "a self-study mathematics (calculus) refresher course" designed for completion in about 150 hours [NPS Catalog, 1972]. Courses for credit or as part of a degree program were not initially offered. There was no broad institutional support for a distance education program. However, the post-Vietnam era was a time of change at NPS. A study was chartered in 1972 to determine the role of graduate education in preparing Naval officers for the future, to study career management policies regarding integration of graduate education, and to recommend changes to enhance the effectiveness of NPS. One of the critical findings of the study was the "Navy's advanced education system . . . makes no provision for maintenance and expansion of individual expertise it advocates, fosters and develops" [Education Study Committee, 1973]. In other words, the focus was on resident-based degree-granting programs with no support for graduate-level learning outside traditional settings. A partial response was the establishment of the NPS Continuing Education Office in 1974. It was to be a "means of providing extended educational services that will more comprehensively fulfill the school's assigned mission" [NPS Catalog, 1984; NPS Catalog, 1989]. Not only did this expand on graduate preparatory courses, it also included "self-study credit courses off-campus and professionally relevant short courses" [NPS Catalog, 1984; NPS Catalog, 1989]. The institutional support for offering non-resident courses for credit was in place. There were nearly one hundred courses offered every year, with representation from every department [Catalog of Self-Study, 1986]. Each course consisted of a text book and a "study guide" that included learning objectives, study procedures, study questions with answers, exercises with solutions and a self-test with solutions [Catalog of Self-Study, 1986]. The intent of the study guide was to provide students with "clear statements on what to learn, explicit instructions on how to learn it, and feedback that tells them if they are learning properly" [Catalog of Self-Study, 1986].

However, as a whole, the Continuing Education Office was not very successful. Taking a self-study course for credit (as opposed to a suggested "just review, non-credit" option) required the student to find and engage with "a qualified tutor" [NPS Catalog, 1989; NPS Catalog of Self-Study, 1986]. The goal was clearly on non-credit refreshers so officers could "enhance selection for postgraduate education, enhance performance in early phases of graduate education, and reduce course requirements in curricular programs at the Naval Postgraduate School" [NPS Catalog, 1989]. In fact, the *Catalog of Self-Study Credit Courses* [1986] itself states the purpose for completing courses was "general improvement of personal skills, [to] prepare for entry into Naval Postgraduate School curricula or other full-time graduate education programs, [to] qualify academically for a wider range of graduate curricula (Navy officers improve their APC)." Academic Profile Code (APC) was (and still is) the primary determiner in the officer admission process at NPS. It is a 3-digit code reflecting a students' overall performance as an undergraduate, and the level of achievement in mathematics and in physics-based engineering. Improving that score was a focus of the courses offered via the Continuous Education Office. Further, the courses themselves did not represent single stand-alone courses, identical to their resident counterparts. Rather, a 3- or 4-course sequence would provide the equivalency of one on-campus course [Catalog of Self-Study, 1986]. So, there was no intention for a student to complete a non-resident degree program or to even achieve significant progress toward a resident degree. In addition to a local tutor, a resident NPS faculty member would be "available by telephone" to respond to student questions. The faculty member was also responsible for administering the course by monitoring student progress, grading the final exam and notifying the registrar upon course completion [Catalog of Self-Study, 1986]. There does not appear to be any evidence of a compensation model for the professor so engaged in this non-resident self-study student interaction. Completion rates for the self-study courses were less than 5% [Hammond, 2011]. Because of budget limitations and the departure of key personnel, the Continuing Education Office was disestablished in 1989 [Command History, 1989]. However, that was not the end of all correspondence courses at NPS. In 1990, the Department of Aeronautics and Astronautics offered a "three-credit, graduate-level self-study course to all military officers and civilian employees of the federal government" on aircraft combat survivability [Howard, 1990]. The course was designed by Professor Robert Ball, based on his book used for a resident class of the same name [Howard, 1990]. That course did achieve some success, but it was slow-going early on. Of the 30 students who started the first aircraft combat survivability course, only 4 completed it [Ball, 1993].

In 1992, a thesis student conducted a feasibility study of using video-conferencing technology in support of distance education "in order to reach more uniformed officers and federal civilians with graduate education" [Owen, 2003]. The study concluded that the technology was available and cost effective, and that NPS had the "professional know-how and expertise to incorporate VTE as a distance learning business enterprise" [Owen, 2003]. The first mixed-mode courses for off-campus students started when the Dean of Science and Engineering, Gordon Schacher, worked with the chair of the Department of Aeronautics and Astronautics, Daniel Collins, to look at "technologies to that could replicate the resident experience for remote students" [Hammond, 2011]. There was no strategic plan or central guidance from the administration. So, the Dean gathered up some funds and with the help of Harry Thomas, the school's senior audiovisual technician, they purchased and installed two PictureTel Concorde 4000 VTC systems in two classrooms in Root Hall. This included cameras, microphones, document cameras, and large-screen monitors [NPS, 1996]. The classrooms retained the capacity for 24 resident students [Koczela & Walsh, 1996]. They also purchased and installed a PictureTel M8000 video bridge multipoint conferencing server (MCU) to support multiple sites dialing in on a VTC [Koczela & Walsh, 1996]. These two classrooms represented "the most current VTE dial-up technology at the time" [Owen, 2003]. The first VTE (video-tele-education) courses were part of a Master of Science in Aeronautical Engineering in the summer of 1994. There were 18 students from Naval Air System Command (NAVAIR), all Department of Navy civilian employees [OCL, 2003; Hammond, 2011]. Professor Emeritus Robert Ball was the first instructor, teaching the course "Aircraft Combat Survivability" [Hammond, 2011; Ball, 2011; Shull 1994; Jones, 1994; Kuska, 1996]. The next degree program offered was a MS in Software Engineering via the Department of Computer Science. The first software engineering cohort started in 1996, with an enrollment of 28 students, mostly Navy civilian employees [OCL, 2003]. Also in 1996, the Department of Electrical and Computer Engineering added a MS in Electrical Engineering [NPS, 1996]. The Systems Management Department offered several short courses that provided the "equivalency" of Defense Acquisition University (DAU) courses, starting in 1997 [Owen, 2011; OCL, 2003; NPS, 1996]. The appeal of these courses for the Navy's acquisition community was that it was a means to complete the educational requirements specified in the Defense Acquisition Reform Act (DAWIA). Students could complete courses in different acquisition fields in order to advance in certified levels – a set of stepping stones in the career path of many DoD civilian employees. The distance learning programs were first officially included in the NPS course catalog for academic year 1998 [NPS Catalog, 1998]. The degree programs offered in the Departments of Aeronautics and Astronautics, Computer Science, and Electrical and Computer Engineering along with the Department of Systems Management short courses were listed [NPS Catalog, 1998].

These efforts mirrored similar efforts at other institutions that were using VTE for course delivery at about the same time. It was not much different than a correspondence course enhanced with some student-instructor interaction via video-conferencing. Material was exchanged between instructor and student via email, the postal service and fax [Koczela & Walsh, 1996]. A traditional classroom configuration was used – instructors could use a chalk board or whiteboard, but it was almost impossible to see at the student's end. Fortunately, the capability to connect a computer's output to the VTC was a boon, as was the availability of document cameras. With document cameras, lecture material, in the form of any written document or overhead slide could be shared with remote students. Scan converters in the document camera made presentation software running on PCs easier to share. The lectures were video-taped, so if a student missed a lecture, he could request the tape be mailed to him. Unfortunately, that could take several days, but better than not having a recording at all.

Those early video-conferencing systems suffered from many technical issues. While the PictureTel codecs were robust and well-behaved, the supporting systems were not. A control system that allowed instructors to switch between multiple cameras, change inputs and interact with the remote sites was unreliable. It crashed often and was not user-friendly. There were many problems in connecting to remote sites. With a MCU on campus, the preferred mechanism for connecting was to have remote sites dial in. However, because some locations had proprietary networks and unreliable ISDN connections, that was not possible. Dialing into a remote site was always problematic [Hammond, 2003; Hammond, 2011; Owen, 2011; Owen, 2003]. In one instance, NPS was required to link to NRaD in San Diego (now SPAWAR Systems Center Pacific) via the Chief of Naval Education and Training office in Washington, D.C., who in turn connected to NRaD [Koczela & Walsh, 1996].

Additionally, there was no institutional support for faculty which prevented any cross-campus effort to "understand the technological, pedagogical, and financial issues associated with distance learning" [Owen, 2003]. Teaching via VTE and redesigning courses for DL is not easy; with no campus-wide support, the pioneers were learning by experience and that was often painful [Ball, 2011; Owen, 2011]. In fact, there were no formal instruction manuals for using the videoconferencing equipment in Root Hall and instructors from all departments arranged personal training from Professor Dan Collins [Koczela & Walsh, 1996]. Lessons learned by some faculty in transitioning their courses to DL were not captured or shared. There was no provision for additional funding for the first NAVAIR students [Hammond, 2011], so the faculty had to rely on funds they received for residents (arrangements for funding were made by 1997 [NPS Catalog, 1997]). The programs were designed to be 'lock-step' for all students, with a schedule mixing resident students in a class with remote students [Koczela & Walsh, 1996]. Unfortunately, attending three 1-hour classes a week is simply not workable for remote students (who are only part-time students and full-time employees at their commands). These issues resulted in graduation rates that were "abysmal" in the first cohorts [Hammond, 2011]. The first software engineering graduates were a group of students from SPAWAR in San Diego: 12 in 1997 followed by another 4 in 1998 [NPS Registrar, 2011]. There were only two electrical engineering graduates in that time frame [NPS Registrar, 2011]. Records of course enrollment imply a graduation rate of about 50% in the software engineering program and about 30% in electrical engineering, but one cannot draw solid conclusions by comparing enrollment data to graduation data in that time frame because enrollments were 'per class' versus 'per program.' Overall, there were unclear expectations for students and faculty, and course effectiveness was unsatisfactory [Owen, 2003]. Because of these many problems, the new chair of the Department of Aeronautics and Astronautics, Gerald Lindsey, stopped DL in his department in 1999 [Hammond, 2011] (the one course on aircraft combat survivability was offered again in 2002 separate from the degree program [Couch, 2011]). However, the Computer Science faculty and students seemed more amenable to working with the technology and continued their DL efforts and the software engineering program continued. Still, there was no centralized, campus-wide strategy. The programs were "entrepreneurial, department-driven" in which individual departments would recognize some appetite for this type of program and solicit for students and funding [Koczela & Walsh, 1996]. After more than two years of distance education using video-conferencing, very few students, faculty or administrators were even aware of its existence [Koczela & Walsh, 1996]. Nevertheless, the VTE programs did grow. A Master of Science in Program Management was added as a distance degree program and two additional classrooms were outfitted with video-conferencing equipment and the original video bridge was replaced with a 16-line unit [Owen, 2003].

The real change in DL at NPS started in early 2000 when Undersecretary of the Navy Jerry Hultin asked the Systems Management Department to join the Education Consortium for Product Development Leadership in the 21st Century, abbreviated as PD21 [Owen, 2011]. The goal of this consortium was to develop a professional Masters Degree program in product development which would be a "synergy between the disciplines of engineering and management" [Frey *et al*, 2000]. The program would be based on MIT's System Design and Management Program. It was the connection between engineering and management that attracted Undersecretary Hultin to the new program [DoD, 2000]. With such an education, civilians in the Navy's acquisition workforce would be better prepared to successfully address the challenges of acquiring weapons systems in the new century. Original consortium members included Massachusetts Institute of Technology, the Rochester Institute of Technology, and the University of Detroit Mercy [Frey *et al*, 2000]. For NPS to join the group and be able to grant degrees in System Design and Management, or Systems Engineering Management, was like having a franchise with MIT. NPS has a history of partnering with other schools, dating to its founding as part of the Naval Academy (MIT, RPI and Columbia University were mentioned above). Still, the process to prove NPS was capable of establishing and maintaining the program was not an easy one. The Systems Management Department established a working group led by Professor David Lamm and Walter Owen to engage the PD21 consortium, to establish a degree program as a "franchisee" of MIT, and to deliver the first courses via VTE based on the model they had established for DAU equivalency. That was no easy task. The challenges to be overcome included 1) the interdisciplinary nature of the degree itself, 2) organizational resistance to change, 3) establishment of administrative and technical support for students, and 4) establishment of procedures for financial management [Owen, 2011].

In this instance, the technology was less of a challenge than resistance met across campus. Because of the interdisciplinary nature of PD21, faculty and department chairmen from the business and management domains would have to come to agreement with those in engineering [Owen, 2011]. The program would not be 'owned' by one department, but would be administered by a team of individuals from the various departments involved. The expected institutional inertia made this almost impossible. However, support from NPS Provost Dick Elster made it possible. The solution was that the program would be administered by the Systems Management Department and faculty from the School of Engineering and Applied Science would develop and deliver the required courses on engineering and design. However, in those days, much course material consisted of binders full of papers and overhead transparencies. "Transitioning" to a VTE-based delivery mode represented a not insignificant commitment of faculty time. (Some faculty at the University of Chicago avoided the correspondence program there in the 1890s citing almost identical reasons.) And, there was skepticism about the effectiveness and quality of DL itself. More than one faculty member said "it's not really education if the students aren't on campus" [Koczela & Walsh, 1996]. To "lure" faculty, an offer was made to provide a bonus of 50% more than the usual amount of funding for each course taught. Additionally, a half-quarter's worth of funding was provided before the start of instruction to support course development time [Owen, 2011].

Even though VTE had become an accepted education delivery mode, it was still in its infancy. There were many remote locations with their own procedures to support remote education and students would have to share video-conferencing resources with the rest of their own organizations. Much trial and error went into resolving dialing and multipoint conferencing issues. The purchase and installation of more VTC suites on campus and the addition of more ports on the MCU bridge helped. Scheduling issues were mostly resolved by abandoning the traditional university scheduling of 3 hours of weekly lecture spread over three days (like Monday-Wednesday-Friday). Instead, the course meetings would take place in a 3-hour block of time one day a week. This eased the burden for the students and their own organizations' video-conferencing support personnel.

The administrative support for students and faculty were also not conducive to a large DL population: "current academic policies and tools available to develop, manage, execute and assess distance education programs [were] inadequate" [Roberts & Owen, 2009]. The Continuing Education Office, which could have helped, had been disestablished in 1989. Further, the processes of registration, buying textbooks, initiating email accounts and everything else we take for granted for resident students simply did not exist for non-residents. It was through the near-heroic efforts of the Registrar, Tracy Hammond, that the first cohort was accommodated [Owen, 2011]. However, it was the result of "putting band-aids on everything" [Owen, 2011].

Finally, they faced the most challenging aspect of working at any graduate education institution: money. Something must be said about NPS' unique financial position. As a Navy organization, it is mission-funded. That is, NPS' budget request is rolled in with the Navy's budget, which is rolled in with the Defense Department budget, which eventually becomes part of the President's budget submitted to Congress every year. When the budget is approved, NPS has authority to execute what was approved as "mission funds." However, NPS is unique. In addition to mission funds directly sent to the command for operations, maintenance and some capital purchases, NPS can accept "working capital funds" from other commands. That is, other organizations within the Defense Department and federal government can transfer funds for specific research or other work done on campus. So, the financial management system existed to support the receipt, execution and tracking of those funds for reimbursable research. However, the concept of receiving funds for reimbursable education was new. Certain aspects of the financial system and rules for managing funds needed to be tailored. The NPS comptroller saw the advantages of doing so, became a proponent of the PD21 program, and modified existing rules and procedures to enable reimbursable education.

When there was enough institutional and academic support, MIT and NPS signed a memorandum of agreement admitting NPS into the PD21 Consortium and formally established the degree program for a MS in Product Development [DoD, 2000; MIT, 2001]. The first PD21cohort started classes in September 2000 with 25 students from each Navy Systems Command [Owen, 2011]. "The PD21 program design actually laid the foundation for subsequent DL programs (MSSE, EMBA, etc…) and was the first program to actually employ a executive style delivery mode (back-to-back classes on the same day), first with a standard faculty compensation model, first with a standard set tuition price and first program to allow Defense contractor enrollment" [Owen, 2011]. There are many similarities in this early experience at NPS with those at other campuses. The lack of organizational infrastructure to sustain the University of Chicago's correspondence outreach program was similar to those challenges to establishing the new PD21 program. Establishment and sustainment of an "effective management system" and "acquisition of teaching skills" are important to a successful program [Burge, 2008]. Starting a large program was chaotic, requiring institutional changes against sometime fierce resistance This is reflective of what Burge [2008] described as "having to navigate the squalls and tempests of innovation, scaling up institutional operations to meet student demand and access criteria, enduring critiques from traditionalist colleagues."

One can also see parallels with the introduction of new technology in other domains. The classic story of LT Sims' naval gunfire at sea (as outlined by Morison [1966]) provides some elements we see in the PD21 story and other early adopters of DL at NPS. For those unfamiliar with this story, in 1899 a junior officer in the United States Navy, LT William Sims, met an admiral in the British navy who had instituted "continuous aim" gunfire on his battleships that dramatically improved his own hit ratio and the British were willing to share the technology. LT Sims believed that this information would be welcome news to his superiors and the War Department. His efforts were ridiculed and opposed by Navy leadership. It is only after President Roosevelt became personally involved that Sims' technically superior designs gained acceptance years later [Pierce, 2004; Morison, 1966]. First, the essential idea for change occurred in the environment which contained all the necessary elements, and there was a mind prepared to recognize its possibilities [Morison, 1966]. In the case of NPS, there was not really one mind, but several. And, the idea to establish a large program came from outside the organization (Undersecretary Hultin). Still, video-conferencing technology existed, it had been used for education elsewhere, but there was that first instance at NPS. The basic elements were there in the environment and were placed there by people who were interested in design for its own purposes [Morison, 1966]. If we draw a rather large boundary regarding 'environment' in this instance, it is not too hard to see that video-conferencing supporting meetings for business or any other endeavor existed and it was known to NPS faculty. We also have the 'classroom' as a kind of system and the institution itself as another kind of system. There are systems within systems here. The elements were brought into successful combinations by people of the 'right temperament' [Morison, 1966]. A few heroic figures assemble the elements to reach some kind of success. There was a team of people acting at NPS – faculty, VTC support personnel, administrators – bringing their own elements into alignment for a shared vision. The earliest adopter was Professor Ball. He developed the self-study course "An Introduction to Aircraft Combat Survivability" in 1989 with the first offering in 1990 [Ball, 1993; Howard, 1990]. He had also conducted 16 short courses on the same topic at remote locations like NAVAIR, the Air Force

Materiel Command and the Army Aviation and Troop Command [Ball, 1993]. So, recognizing "distance learning is the wave of the future" [Jones, 1994] and volunteering to be the first to teach using VTC were completely within his character. In describing his program, he used phrases like "we have been educating military officers . . . for 15 years and that we have the only aircraft survivability textbook," and to make sponsors "aware of our relevance, uniqueness, and importance" [Ball, 1993], in spite of the fact those were all his own solo efforts – there was little "we" involved. It should be noted that *The Fundamentals of Aircraft Combat Survivability Analysis and Design*, second edition, is still the only textbook on the subject. The original self-study course survived its slow start and enjoyed a 100% completion rate in 1992 [Ball, 1993]. The course is still available via DoD's Joint Aircraft Survivability Program [SURVIAC, 2011]. There was a NPS Distance Education Committee, chaired by Professor Maurice Weir, but the real driving force was Tracy Hammond. In one nine-month span in 1996, Mr. Hammond conducted all twelve meetings and Prof. Weir was not present [Koczela & Walsh, 1996]. More to the point, Tracy Hammond, Ted Lewis, and Dan Collins were the people on campus "most behind distance education" [Koczela & Walsh, 1996]. In our case, the technological side was challenging, but the 'people-ware' elements of the final system were more so. There is opposition to any new invention by those who have identified themselves with the old ways [Morison, 1966]. In our case, some faculty and administrators were skeptical of DL itself and resigned themselves to oppose it [Koczela & Walsh, 1996]. The perceived threat to job security and the fear of machine-professor-enslavement have already been discussed. Those attitudes still exist on campus [Roberts & Owens, 2011]. However, perceptions of shifts in power centers are equally motivational. "For distance education, group dynamics can create pockets of power across an organization. For academic institutions, the struggle may be most intense between two academic special interest groups: the entrepreneurial (trying to gain power and influence to accelerate distance learning) and the traditional (trying to slow down or curtail distance learning)" [Roberts & Owens, 2011]. Finally, the conflict between those opposing a new technology or its new application and those promoting it are resolved by "an appeal to a superior force" [Morison, 1966]. This is where our story is not exactly like those described by Morison in which the proponents initiate such an appeal to a superior outside their own organization. It was the outside superior force itself (Undersecretary Hultin) that had initiated the PD21 efforts. However, there was still plenty of opposition on campus. The provost's support may not have been enough to completely resolve the conflict, but it was enough that the project moved forward to some successful conclusion. Support from key stakeholders on campus like the Registrar, several department heads and other administrators turned the tide, and DL was launched at NPS.

Maturation and Institutionalization of DL

The successes of the early adopters became somewhat institutionalized in the early years of the 2000s. The keys for success came into being as lessons were learned and administrators worked with faculty to establish distance learning policies and taking a total systems approach. For students, the enrollment process was codified and web-based administrative support tools were provided [ITACS, 2006]. Effectiveness studies on the use of technology, administrative support and customer engagement were completed [Owen, 2003]. Support for both faculty and students came when the Office of Continuous Learning was established in 2000 to "identify continuous learning requirements and opportunities, and assist, as useful, faculty or Departments/Groups with their efforts to meet the educational needs of their customers" [Elster, 2000]. They took over some management responsibilities regarding receipt and management of funds. They assisted students with acquiring text books, enrollment, and mailing of any paperwork or other material. Most importantly, they helped support maintaining the quality of education. First, just as a clearing-house of lessons learned for faculty, then they offered formal courses for faculty on how to design a distance learning course and how to make the most of video-conferencing and mixed delivery strategies. Even though there is one office on campus with these responsibilities, the issues of faculty compensation, institutional accreditation, program ownership and intellectual property rights have not been completely resolved, but there are processes in place to address individual challenges as they arise [Roberts & Owens, 2009; Roberts & Owens, 2010; Owen, 2011]. Issues with purchase and maintenance of the VTC systems themselves became centralized when Tracy Hammond was appointed as the first full-time Director of Instructional Technology in 2005 [ITACS, 2006]. Since then, annual upgrades have been made to the VTC systems, including replacement of obsolete equipment like the original MCU [ITACS, 2007] and the addition of 3 more VTE systems in 2009 [ITACS, 2010].

Other than the VTC systems themselves, the key technology enabler at NPS has been the introduction of computers in the classroom – originally for residents. It could be argued that using computers in the classroom was inevitable, especially for courses in engineering and the physical sciences. There are many software tools that help engineers and scientists work. They vary from general-purpose modeling tools like Extend and Arena to those that are more narrowly focused like Antenna Magus from CST or the EEsof suite from Agilent. It is only natural to bring these tools into the classroom to support lecture and all kinds of student-instructor interaction. For all instructors, transferring lecture material to presentation software enables great portability between the resident classroom and the DL classroom. The point here is that doing anything with a PC for resident students translates directly into having the same interaction with DL students. (There are those who complain this has made the classroom experience "death by PowerPoint" for the students, but that is a topic for another day.) However, that also leads to the need to share electronic course materials with students. Emailing this material can become burdensome. An online learning management system was needed. In 2002, NPS adopted the Blackboard web-based learning management system "as a method to deliver asynchronous classes to distributed learning students taking NPS certificate programs" [ITACS, 2009]. As NPS outgrew Blackboard, a committee was formed in 2008 to seek a replacement [ITACS, 2009]. Sakai replaced Blackboard as the campus-wide learning management system via a 1-year transition that completed in October 2010 [ITACS, 2010].

Another technological advance adopted recently is a web-based virtual collaboration tool. Traditional VTC has many capabilities to support distance education. It supports two-way conversations, demonstrations, white-board use and sharing some documents. At NPS, the VTE lectures were taped and those recordings were mailed to remote sites upon student request. This was almost a step backward to the days of traditional correspondence courses in which course material moved via the postal service. The solution was found in 2004 when the transition started to make class recordings available in Windows Media Video (.wmv) format via the commercial tool Vbrick (http://navcast.nps.edu/) [ITACS, 2006]. Another drawback with VTC is that the instructor must use a scan converter to translate a computer's video output to the correct format for ISDN-based standard video-conferencing. Doing so reduces the quality of the video, and hence reduces the readability of anything shared on the computer. The other drawback is that the students cannot 'take-over' any application from their location, but must rely on requesting the instructor to walk through specific issues of their own interest. As discussed previously, there are several web-based video-conferencing and collaboration support tools available that could be used for DL. In early 2006, the Office of Continuous Learning conducted a pilot study of Macromedia Breeze [ITACS, 2008]. (When Adobe acquired Macromedia in late 2005, the application was rebranded as Adobe Connect. However, NPS had already started some work with it before the rebranding.) In spite of some favorable reviews by faculty, there were serious concerns about cost, support and scalability [ITACS, 2008]. After studying several other alternatives in 2007, NPS adopted Elluminate, a synchronous collaboration systems that provides "two-way audio, Video over IP (VoIP); PowerPoint and/or Keynote presentation; web browser; desktop sharing; application sharing; audio and/or video streaming polling, testing and/or survey tool; whiteboard; session recording and/or archiving capabilities" [ITACS, 2008]. Among the advantages over Breeze and other tools is that Elluminate "excels in low bandwidth environments (12kbs), uses Learning Management Systems integration, is Navy Marine Corps Intranet (NMCI) compliant, has a web scheduling interface and compression rates of 1 hour sessions – 5 – 10 MB, podcasting features, evaluation forms, an enterprise licensing option . . . and uses Java virtual machine — all at a total cost of $105,000, which is less than half its nearest competitor" [ITACS, 2008]. With Elluminate, the students can directly manipulate the instructor's computer (and vice versa). (The author was among the first adopters in October 2007, using VTC and Elluminate at the same time. A summary of that experience was shared with other faculty in a presentation in 2008 [Miller, 2008].) The real power of Elluminate is that having an application installed and running locally is not required. That is, our students who do not have MATLAB, for instance, can still work with it in the classroom. A student can request control of the instructor's shared application and run it as if it were on his own computer. This might even be considered an advantage over resident learning because the sometimes frustrating interaction of "what did you mean, I cannot replicate what you just said" does not occur. Instead, the student can demonstrate exactly what his issues or problems might be, and the instructor can see it directly. Another advantage is that DL students can save the virtual whiteboard and the chat window for individual study after class. (This feature is available in Elluminate and in Adobe Connect, but the author has not seen a successful demonstration with other similar tools.) And, like VTE, class recordings are available. Elluminate sessions can be recorded and are available for viewing in their native format. Just as importantly, Elluminate can enable the establishment of a learning community. Elluminate sessions just for students to meet with each other, without instructor 'interference,' can be established. The rich interaction of voice, video, chat, whiteboard, and application sharing are available for their use. Elluminate is not without its own drawbacks and its adoption has not been campus-wide. Several programs, most notably, those offered by the Graduate School of Business and Public Policy, have preferred the continued use of VTE. Most of the students in those programs are assembled into cohorts from one command. Because they are at one location (versus being geographically distributed), student-to-student interaction is promoted by VTE. They must all come together in one meeting room at their location to attend a video-conferencing lecture, and thus enjoy the "feel" of being in a classroom together, which is another way to help establish a learning community.

At NPS, studies comparing the attitudes of students, faculty and administrative staff have led to improvements in the quality of coursework and standardization of administrative support processes [Roberts & Owen, 2009]. Findings indicate that "although distance education has its 'shortcomings' faculty recognize its importance in education and understand its potential value overall" [Roberts & Owen, 2009] and DL will continue for the foreseeable future. The keys to success have been bringing together technology, pedagogy, and administrative and financial support [Owen, 2011].

Current Status

In 2010, there were 1148 (819 degree & 329 certificate) distance students participating in distributed degree or certificate programs, compared to 1557 resident students [NPS Factbook, 2010]. Over 42% of the student body is not on campus. Table 1 illustrates the trend in DL student population.

Table 1. Degree Program Students by Type of Enrollment [NPS Factbook, 2010]

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Full Time Resident	1283	1279	1269	1244	1314	1481	1560	1732	1739	1566	1489	1557
Distance Learning	95	111	180	221	247	322	523	501	847	719	707	819
Total	**1378**	**1390**	**1449**	**1465**	**1561**	**1803**	**2083**	**2233**	**2586**	**2285**	**2196**	**2376**

The number of resident students remained relatively stable, with some growth in the 2003-2007 period. The DL student population increased dramatically, growing by an average of nearly 16% annually. The Center for Educational Design, Development, and Distribution (CED3 – the new name for the OCL) has continued to provide administrative and professional support [EER, 2010].

Technology for DL has also grown. It started with the purchase of the first VTC systems and, at the end of 2010, there were10 VTE systems supported with a 48-port MCU and 165 ISDN video-conferencing lines. Over 6200 class hours were recorded and streamed via the Internet. Nearly 6000 courses were hosted on the learning management system [NPS Factbook, 2010]. Table 2 summarizes the trends in course delivery.

Table 2. Trends in Technology Support [NPS Factbook, 2010]

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Number of LMS Courses	138	252	323	408	467	578	636	706	1124	1433
Hours of Streaming Video				2890	3467	4160	5233	7040	11677	12717
Number of Web-based Lectures							420	2044	3702	4733

The LMS courses in Table 2 count courses created and maintained on both Blackboard and Sakai. Streaming Video refers only to VTE courses available via VBrick and the "web-based Lectures" refer to Elluminate recordings. In 2010, 38% of course sections used video-teleconferencing, 19% used web-based Elluminate software, 19% are hybrid, 18 % were asynchronous, and 6% were taught offsite in person [EER, 2010].

The Center for Educational Design, Development, and Distribution (CED3) continues to support faculty in designing and delivering high quality courses. A good course - good learning - is enabled by a well-designed course in which the technology serves to support and not impede knowledge retention. The instructor is responsible for creating such an environment and the student is responsible for making the most of the tools at his disposal. Burge [2008] emphasizes that new practitioners in the field of DL make use of lessons learned from more experienced faculty. Maintaining "cordial interpersonal and interdepartmental relationships" can help [Burge, 2008]. A recent example of interdepartment and interorganizational collaboration is the development of the first TEAL, or Technology Enhanced Active Learning, classroom on campus. First implemented at MIT, TEAL "facilitates collaborative learning by situating students in well-orchestrated groups, each with its own dedicated audio-visual system, workspace and whiteboard" [NPS Annual Report 2010].

One more term used in the literature is 'distributed learning.' Bates [1995] characterizes it as

> "… a learner-centred approach to education, which integrates a number of technologies to enable opportunities for activities and interaction in both asynchronous and realtime modes. The model is based on blending a choice of appropriate technologies with aspects of campus-based delivery, open learning systems and distance education. The approach gives instructors the flexibility to customize learning environments to meet the needs of diverse student populations, while providing both high quality and cost effective learning." [Bates, 1995]

In Bates' view, the terms 'distributed learning' and 'distance education' do not mean the same, though many people use them interchangeably. That is the case at NPS in which the term "distributed" has replaced "distance" in many documents (but not all) describing the program in an effort to de-emphasize the geographic distances in favor of the two-way interaction.

Challenges, Limits, and Potential Solutions for Technology and DL

Some governance issues still remain. NPS continues to have three different primary funding streams for DL programs. "This diversity of funding streams leads to differing financial models and management approaches" [EER, 2010]. Graduation rates are still lower among non-resident students than resident students [EER, 2010]. Among other potential solutions, the establishment of a DL Council has been recommended to re-assess policy, coordinate services and monitor assessment results for all DL activities across campus [EER, 2010].

In spite of the immediacy of the interaction of web-based conferencing tools like Elluminate, there is still something somewhat unsettling about any education in which face-to-face interaction is eliminated. There is a lack of "feeling" of being in a class or a lack of social cues. Forming a learning community is almost impossible. Like VTE, there is a certain TV-studio result. That is bad for students, because it encourages "watching" the class instead of participating in class. And, Elluminate is somewhat like a computer game – there is a lack of connection between a student and his instructor and his classmates. The next step in this technology is a 'fix' to provide a more realistic environment. It should look and sound like a classroom or conference room with each student and instructor represented by a graphical self-representation. Multiplayer virtual worlds, in which users interact with each other via avatars in a computer-created simulated environment, offer some promise. The one most discussed in distance education literature is Second Life, an online virtual world launched by Linden Labs in 2003. It has been extensively explored for several undergraduate and graduate-level programs. In fact, to promote its use for education, the Second Life Best Practices in Education conference in 2007 was held *in* Second Life [Luo & Kemp, 2008]. In 2007, "more than 150 colleges in the United States and 13 other countries [had] a presence in Second Life" [Foster, 2007]. Instructors and students create a free account, select an avatar and user name, then "enter" the virtual world via their web browser. Then, they can "meet" at a predetermined destination by directing their avatars to go there. Participants can "see, hear, attempt new behaviors, use and create objects" [Wagner & Ip, 2009]. Its greatest advantage over traditional VTE and web-based meeting tools is the freedom of interaction between participants. Virtual voice-based and text-based interaction between motional avatars imitates real-life personal interaction better than any other technology to date. Interacting with customizable avatars in virtual worlds makes distance learning more realistic and feasible [Wagner & Ip, 2009]. This promotes stronger interaction among students, improves team-building and oral communication skills, broader participation in class activities [Luo & Kemp, 2008]. Second Life appears most valuable in generating experiences that are then used in reflective exercises outside of Second Life [Luo & Kemp, 2008]. The experiences in Second Life can also be almost identical to their real world analogs. Because Second Life has its own economy in which users exchange goods and services directly with each other, business students can "build on-line, revenue generating businesses with modest financial investments" [Wagner & Ip, 2009]. The exercise is very realistic. Their virtual businesses are available to the entire on-line community and provide virtual goods and services in exchange for Second Life's currency, Linden dollars (Linden$ or L$), providing "good practice activities for students to demonstrate their business skills" [Wagner & Ip, 2009]. Other successful courses include ethnography, writing and composition and architecture [Foster, 2007]. The interaction, constructive learning and learner-centered approaches offer engagement which motivates students, even outside the classroom. And, we know that a motivated student is generally a good student.

Second Life is not without its disadvantages. These include a steep learning curve, distractions in the virtual world and technical problems [Luo & Kemp, 2008]. Wagner & Ip [2009] report "student frustration with platform stability or restrictions on the numbers of objects ('prims') that can be used. The greatest drawback of Second Life is that, just like in the real world, very little is free. After creating their avatars, users must clothe and care for them. Meeting classes in public places is free, but that is like meeting in any real world public place, with its attendant distractions. A dedicated classroom with restricted access would have to purchased or rented. In teaching one class, "educators usually spend about $1,000 to own virtual 'land,' and many shell out hundreds of dollars more buying virtual goods like furniture and clothing" [Foster, 2007]. Importing files for sharing is relatively inexpensive. Images can be imported at a cost of L$10 (or about 4 cents). A typical set of slides or document is converted to a set of images (each page as a separate .jpg file), then they are uploaded as part of the user's "inventory" for avatar use. Finally, the user creates an object like a flattened cube and "paints" the image as a texture onto the object. If one has a 50-slide presentation, uploading it would cost L$500 or $2. And, there is no means to manipulate or mark it up in Second Life. Recently, several tools have been made available in the Second Life marketplace which enable the direct import of Powerpoint and pdf files and also feature some white-board functionality [Hodge *et al*, 2011].

The next step in DL technology education may or may not be virtual worlds like Second Life. There is strong support available directly from Linden Labs and many institutions maintain a presence in Second Life, including Ohio University, Bowling Green State University, Northern Illinois University, University of Edinburgh and East Carolina University [SLED, 2001]. It supports presentations and discussion like any other web-based meeting tool, it offers better interaction and it enables unprecedented engagement through role-playing. These could be immediately useful in DL courses at NPS that already employ a quarter-long role playing exercise, like Professor Dick Doyle's courses on Defense budgeting or Professor Lawrence Shattuck's courses on human systems integration. However, it is probably not a good fit for NPS, campus-wide. Most of our DL students use their computers from work; at Navy facilities, that means dealing with NMCI (Navy-Marine Corps Intranet). For security reasons, many ports and protocols are blocked at local firewalls, users have no administrator rights and throughput can slow to a crawl. Webcams and microphones are not allowed at some locations. Without administrator rights, students cannot download and install the Second Life client needed to communicate with Linden Labs servers. Reviews by engineering students and faculty have been mixed. For the near future, NPS' use of Second Life (or a similar virtual world) is unlikely.

What does show promise, especially for the 'hard' sciences and engineering? There are those who say DL works only for those courses in which no hands-on labs are required. And, removing a lab experience diminishes the quality of learning. The challenge, then, is providing a real (not virtual or simulated) hands-on experience for off-campus students. Strategies have included shipping Mindstorms and other lab kits to remote locations. However, the expected issues of damaging a kit in transit and the possibility of it being lost or not returned have limited its usefulness. NPS' Department of Electrical and Computer Engineering, offering degree programs via DL since the late 1990s, has recently demonstrated remote access to electrical engineering labs for students [Oriti *et al*, 2010]. Oriti and her collaborators [2010] designed and built a Student Design Center (SDC) which allows students to control and measure power electronics and electric drives remotely via their own web browser. The SDC is the "enabling technology" for hardware labs supporting power electronics and machine classes [Oriti *et al*, 2010]. It is based on a standard PC running Simulink/Matlab with Xilinx plug-ins. External electronics include a power supply, a Xilinx development board and two custom printed circuit boards with sensors and analog-to-digital (A/D) converters [Oriti *et al*, 2010]. The configuration was improved later by adding a USB interface for faster and more flexible data processing capabilities [Oriti *et al*, 2011]. For typical students, the use of Simulink with the Xilinx blockset simplifies everything because it automates the process of generating VHDL code. VHDL stands for VHSICs (Very High Speed Integrated Circuits) Hardware Description Language. It is generally written like computer code, but represents a very low level in digital system design by permitting a designer to specify the behavior of devices like state-machines, counters, flip-flops and even individual logic gates. A Field Programmable Gate Array (FPGA) is then "programmed" to run the VHDL code and can thus control any of a number of other devices around it. (Xilinx is one of several firms producing FPGAs and VHDL support tools.) So, the advantage of the SDC is that experience in writing VHDL and working with FPGAs is not required. The student "designs" the power converter control system in Simulink with visual blocks representing control circuit elements. It generates the VHDL code and the Xilinx software generates the final FPGA programming files and then programs the FPGA on the Xilinx development board. This allows "several power converter topologies to be studied experimentally with any combination of control or modulation strategy" [Oriti *et al*, 2010]. Remote students interact with the PC in the lab via a main web server which hosts a Java server engine and a TCL (tool control language) interface to the Xilinx Chipscope Server [Oriti *et al*, 2010]. The web interface was designed to allow users to perform the labs with any web browser. That required three things: only the standard HTTP port is used, no client software is installed on the student's computer, and the instructor must be able to add and manage remote lab experiments [Oriti *et al*, 2010]. The web interface allows for remote control and monitoring of oscilloscopes, and a live webcam provides video of the equipment running. This is a huge step in enabling engagement on the part of the students. Use of design support and simulation tools like Simulink and LabView have allowed remote and resident students to create models and then run any number of simulated exercises involving electronic and mechanical systems. A virtually limitless combination of circuit elements, mechanical actuators and controls, measurement tools and scopes can be "assembled" in the virtual design space. They can be run, modified, and re-run. Having the theory and equations "come to life" with these simulations permits student interaction with the material beyond reading, lecture, and homework. However, they are just simulations. What the NPS ECE faculty has created is a lab in which real equipment can be controlled and monitored remotely. The live webcam allows the student to see and hear the motors stop and start, reacting to his control. On-line support is also readily available. Tabs in the lab web page link to instructions on executing the lab and writing the lab report. A help menu is also available [Oriti *et al*, 2010]. This configuration has enabled power electronics experiments with "buck and boost converters, diode rectifiers, H-bridge inverters, series loaded resonant DC-DC converters, three phase inverters and double bridge regenerative AC/AC converters" [Oriti *et al*, 2010]. Motor drives labs include "variable speed control of induction machines, doubly fed induction motor drives for wind power and ship propulsion applications" [Oriti *et al*, 2010]. Oriti and her colleagues [2010; 2011] follow a classic engineering pedagogy: theory is presented in texts, discussed and simulated in class, and validated through lab exercises. A resident lab technician turns on the power, and the remote students can run all their experiments without ever physically being on campus.

The faculty of ECE accepted the challenge of enabling hardware labs for DL students by developing a novel approach that closely simulates the resident experience and takes advantage of hands-on learning. Like any story of technology evolution, the NPS system for remote access for labs has predecessors. The SDC hardware existed for resident student use for four years before being adapted for DL with the design of the web interface [Oriti *et al*, 2010]. The SDC itself is based on tools that have been used in electrical engineering labs for years: Simulink, the Xilinx suite of tools, and the electric machine lab benches. Web-enabled oscilloscopes have also been available for several years. They engaged the CED3 who helped develop the HTML for the web interface [Oriti *et al*, 2010] which is available via their course site on Sakai [Oriti *et al*, 2011]. Their success is reflected by the fact that the number of students taking the course increased by 40% over 3 years. They are a model for all engineering educators. They combined existing systems in new ways, sought help across campus when needed, ran trials to improve their design and responded to student needs. Most importantly, they adapted the technology available to support their pedagogy and improve the classroom and lab experience for all remote students.

The original challenges of limited interaction and student engagement from the first correspondence courses continue today. They provide opportunities to experiment with new technologies in communication venues to support teaching and learning. "This means bringing learners frequently into action by asking questions, encouraging student presentations, getting students to talk to each other, and in other ways involving them fully in the teaching-learning process" [O'Neil, 2006]. There will be the usual false starts and dead-ends, but there will also be successes. The accepted processes of invention, adaptation and selection driving all technology evolution [Basalla, 1984; Arthur, 2009] are at play. "Those [technologies] that are chosen will be replicated, join the stream of made things, and serve as antecedents for a new generation of variant artifacts" [Basalla, 1984]. The environment in which this happens at NPS is that of graduate-level education for active duty military officers and DoD civilian employees. At NPS, with many of the issues from the mid-1990s resolved and campus-wide support for funding and administration established, faculty can focus on how to use the technology positively. "Although technology should not drive our teaching, technology does drive change" [Bates & Poole, 2003]. In designing a DL course, the key question is then: "How can technology be used or adapted to improve interaction and student engagement, to achieve the course goals?" DL technology will advance along that line: only that which supports the pedagogy survives and becomes widely adopted. That becomes the primary driver. Like any other domain, we see all aspects of technology evolution in the DL domain. It is not necessarily about progress or movement toward some optimum goal. Rather, it is about the adoption of the most-fit set of technology for its restricted environment of education populated by learners, educators and administrators.

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List of References

W. Brian Arthur. *The Nature of Technology – What It Is and How IT Evolves*. Free Press. 2009.

Robert Ball, NPS Professor Emeritus. Personal email. November 1, 2011.

Robert Ball, NPS NPS Professor Emeritus. Memo to PAO. January 21, 1993.

George Basalla. *The Evolution of Technology*. Cambridge University Press. 1988.

A. W. Bates and Gary Poole. *Effective Teaching with Technology in Higher Education*. John Wiley & Sons, Inc. 2003.

A.W. Bates. *Technology, Open Learning and Distance Education*. Routledge.1995

Liz Burge. "'Crafting the future': Pioneer Lessons and Concerns for Today." *Distance Education*, Vol.29, No.1, May 2008.

Denise Casey. "A Journey to Legitimacy: The Historical Development of Distance Education through Technology." *Tech Trends*, Vol. 52, No.2, Mar/Apr 2008.

Chief of Naval Operations Instruction (OPNAVISNT) 5450.210C. "Naval Postgraduate School Mission and Functions." 2007.

Mark Couch, Institute for Defense Analysis, former NPS Professor. Personal email. November 7, 2011.

Richard Elster, NPS Provost. Memo: "ORGANIZATIONAL PLANS" of 24 May 2000.

Andrea Foster. "Professor Avatar." *The Chronicle of Higher Educuation*, Vol. 54, No. 4. 2007.

Daniel Frey, Mark Smith and Scott Bellinger. "Using Hands-On Design Challenges in a Product Development Master's Degree Program." *Journal of Engineering Education*. October 2000.

Department of Defense. News release, No. 262-00. "Navy, MIT Establish Graduate Program in Product Development." May 18, 2000.

D.R. Garrison. "Three Generations of Technological Innovation in Distance Education." *Distance Education*, Vol.6, No.2. 1985.

D.R. Garrison. "A cognitive constructivist view of distance education: An analysis of teaching-learning assumptions." *Distance Education*, Vol. 14, No. 2. 1993.

D.R. Garrison and Doug Shale. "Mapping the Boundaries of Distance Education: Problems in Defining the Field." *The American Journal of Distance Education*, Vol. 1, No.1. 1987.

Graduate Education Study Committee Report. Naval Postgraduate School. 20 July 1973.

Tracy Hammond, NPS Director of Instructional Technology. Interview with Gregory Miller. Skype interview. October 31, 2011.

Tracy Hammond, NPS Director of Instructional Technology. Personal email. May 20, 2003.

Elizabeth Hodge, Sharon Collins and Tracy Giordano. *The Virtual Worlds Handbook: How to Use Second Life and Other 3D Environments*. Jones and Bartlett Publishers. 2011.

Charles Howard. Naval Postgraduate School news release. “Aircraft survivability course offered by Naval Postgraduate School – via mail.” February 5, 1990.

Davey Jones. “Distance learning expands opportunities.” *The Quarterdeck*, Vol. III, Issue 22. June 9, 1994.

Michael Jeffries. “The History of Distance Education.” (http://www.digitalschool.net/edu/DL_history_mJeffries.html, accessed October 13, 2011).

Desmond Keegan. *Foundations of Distance education, 3rd Ed.* Routledge Falmer. 1996.

Desmond Keegan. “Problems in Defining the Field of Distance Education.” *The American Journal of Distance Education*, Vol. 2, No.2. 1988.

Diane Koczela and Dennis Walsh. “Promoting Distance Education at Naval Postgraduate School (NPS).” Master’s Thesis, Naval Postgraduate School, 1994.

Dale Kuska. “Experimental multimedia techniques blend with traditional distance education.” NPS PAO New Release, August 6, 1996.

Jorge Larreamendy-Joerns and Gaea Leinhardt. “Going the Distance with Online Education.” *Review of Educational Research*, Vol.76, No. 4. 2006.

Anthony J. Lease and Thomas A. Brown. “Distance Learning Past, Present and Future.” *International Journal of Instructional Media* , Vol. 36, No. 4. 2009.

Lili Luo and Jeremy Kemp. “Second life: Exploring the Immersive Instructional Venue for Library and Information Science Education.” *Journal of Education for Library and Information Science,* Vol. 49, No. 3. 2008.

Gregory Miller. “DL with Elluminate . . . or Two Years Before the Mast: A Personal Narrative of Life on the Sea of DL.” Presentation for Elluminate Brown Bag seminar hosted by CED3 at NPS. October 2008.

MIT Center for Innovation in Product Develepment. Reports to the President 2000-2001.

Michael Moore and William Anderson. *Handbook of Distance Education*. Lawrence Erlbaum Associates, Inc. 2003.

Elting Morison. *Men, Machines, and Modern Times*. The MIT Press. 1966.

Naval Postgraduate School. Command History. 1989.

Naval Postgraduate School. *Course Catalog Academic Years 1972-1973*.

Naval Postgraduate School. *Course Catalog Academic Year 1984*.

Naval Postgraduate School. *Course Catalog Academic Year 1989*.

Naval Postgraduate School. *Course Catalog Academic Year 1998*.

Naval Postgraduate School. "Distance Learning Programs." Brochure, 1996.

Naval Postgraduate School. "Educational Effectiveness Review for Western Association of Schools and Colleges." (EER) August 2010.

Naval Postgraduate School. AY 2010 Factbook.

Naval Postgraduate School. 2010 Annual Report.

Naval Postgraduate School ITACS Office of Educational Technologies. "Sakai Collaborative Learning Environment Project." Unpublished white paper. January 2009.

Naval Postgraduate School ITACS. "Accountability Report, FY2005 Accomplishments and Challenges." Unpublished report. 2006.

Naval Postgraduate School ITACS. "Accountability Report, FY2006 Accomplishments and Challenges." Unpublished report. 2007.

Naval Postgraduate School ITACS. "Accountability Report, FY2007 Accomplishments and Challenges." Unpublished report. 2008.

Naval Postgraduate School ITACS. "Accountability Report, FY2009 Accomplishments and Challenges." Unpublished report. 2010.

Naval Postgraduate School Registrar. Graduate database query results, "location ≠Monterey, 1996-1999." 2011.

Naval Postgraduate School. *Catalog of Self-Study Credit Courses1986-87*.

Nefsis. "Video Conferencing History." (http://www.nefsis.com/Best-Video-Conferencing-Software/video-conferencing-history.html, accessed October 28, 2011).

Søren Nipper. “Third generation distance learning and computer conferencing,” in: Robin Mason & Anthony Kaye (Eds). *Mindweave: Communication, Computers and Distance Education*. Pergamon Press. 1989.

Office of Continuous Learning (OCL) at NPS. Internal report “VTE Courses-Enrollments1994-2003.” 2003 (unpublished).

Therese DonGiovanni O’Neil. “How Distance Education Has Changed Teaching and the Role of the Instructor.” *E-Leader Conference Slovakia*. 2006

Giovanna Oriti, Daniel Zulaica, Alexander Julian, and Roberto Cristi. “Hardware Laboratories for Power Electronics and Motor Drives Distance Learning Courses.” in Proc. of *IEEE 2nd Energy Conversion Congress and Expo (ECCE) 2010*, Atlanta, GA, September 2010.

Giovanna Oriti, Daniel Zulaica, and Alexander Julian. “Doubly Fed Induction Machine Drive Distance Learning Laboratory for Wind Power and Electric Ship Propulsion Applications.” in Proc. of *IEEE 3rd Energy Conversion Congress and Expo (ECCE) 2011*, Phoenix, AZ, September 2011.

Walter Owen. *A Case Study of Distance Education at the Naval Postgraduate School*. Doctoral dissertation, Golden Gate University, 2003.

Walter Owen, NPS PD21 Program Manager. Interview with Gregory Miller. Phone interview. October 26, 2011.

Darin Payne. “English Studies in Levittown: Rhetorics of Space and Technology in Course-Management Software.” *College English*, Vol.67, No. 5. May 2005.

Terry Pierce. *Warfighting and Disruptive Technologies: Disguising Innovation*. Frank Cass. 2004.

Post Graduate Department, United States Naval Academy. Catalogue of Curricula and Courses of Study. 1915

Ben Roberts. & Walter Owen. “A Case Study of Distance Education at the Naval Postgraduate School.” *World Conference on Educational Multimedia, Hypermedia & telecommunications*. Honolulu, HI. 2009.

Ben Roberts. & Walter Owen. “Challenges in Distance Learning Program Development and Delivery.” *8th Annual Hawaii International Conference on Education*. 2010.

Lucy Roberts. “The History of Video Conferencing – Moving Ahead at the Speed of Video.” Ezine Articles. 2004. (http://ezinearticles.com/?The-History-of-Video-Conferencing---Moving-Ahead-at-the-Speed-of-Video&id=5369, accessed November 28, 2011)

Second Life Educators (SLED). (http://wiki.secondlife.com/wiki/Second_Life_Education, accessed on November 5, 2011).

Harrison Shull. “Twelfth Annual Report on the Status of Graduate Education in the Navy.” Presentation to RADM Thomas Mercer, Superintendent of Naval Postgraduate School. October 1994.

Jennifer Sumner. “Serving the System: a critical history of distance education.” *Open Learning*, Vol. 15, No. 3. 2000.

Survivability/Vulnerability Information Analysis Center (SURVIAC). “Aircraft Combat Survivability Self Study Program (SSSP).” (http://www.bahdayton.com/surviac/survivabilityeducation.htm, accessed on November 2, 2011.)

U.S. Code. Title 10, Section 7041. 1945.

U.S. Department of Education, National Center for Education Statistics. *The Condition of Education 2011*. (NCES 2011)

"Virtual Command, Control, Communications, Computers and Intelligence (C4i) Environment Distance Learning.".*Commerce Business Daily*. 7 Sep 2001.

Christian Wagner and Rachael Ip. “Action Learning with Second Life – A Pilot Study.” Journal of Information Systems Education, Vol. 20, No. 2. 2009.

Robert Wisher, Mattthew Champagne, Jennifer Pawluk, Angela Eaton, Christina Curnow and David Thornton. “Training Through Distance Learning: An Assessment of Research Findings.” Army Research Institute for the Behavioral and Social Sciences. Technical report 1095. June 1999.

Robert Wisher and Curtis Bonk. “Apply Collaborative and e-Learning Tools to Military Distance Learning: A Research Framework.” Army Research Institute for the Behavioral and Social Sciences. Technical report 1107. October 2000.