Advanced Technologies to Enhance Education to Optimize Information Flow Utilization

Mark C. Davis
Computer Engineer
Mooresville, NC
davismc@ieee.org

Dan M. Davis
University of Southern California
5916 Bixby Village Dr, Ste. 88
Long Beach CA 90803
310 909-3487
dmdavis@acm.org

Keywords:
eLearning, Information Flow, Deep Learning, Quantum Annealing

Abstract: *Both the identification of shortcomings in the comprehension of massive data flows and the development of computer-enabled methods of addressing those shortcomings are presented. Experience with new capabilities to amass, manage and deliver virtually limitless information has shown that one of the major barriers to optimal use was the users' inability to assess, comprehend and filter the overwhelming data. A common complaint of users is that they are given too much information, so that it becomes distracting rather than illuminating. A major component of the data transfer issue is the existence of a sort of friction that degrades the best comprehension of the data. The current environment has suggested some supportable contentions: information friction has been ameliorated by technology, despite some restrictions imposed by organizational leadership; the transfer of data is driven more by human proclivities than technical constraints; and this issue is particularly critical in education. Education and training has always been able to improve user comprehension, but the changing environment points to new optimized approaches. Research will be presented that will support paths to identifying and addressing the data comprehension concerns. During current research, a useable avatar technology has been developed to provide similar education and training where needed. This virtual human use makes the approach practicable, as it does not require significant additional staffing and is available anywhere, anytime. Educational and computer simulation projects already fieldable would be extensible to address these issues. High performance and quantum computing efforts help enable this methodology..*

1. Introduction

eLearning is a major hope in addressing the issues that face the DoD's education challenges. While many eLearning issues do not currently involve innovative implementations of simulation technologies, virtually all could do so. The authors maintain that much of this is a result of the frictions in information flows in several different dimensions and in several different stages of the education learning processes. Current DoD approaches to both education and training suffer from the aforementioned frictions. However, this paper addresses the alternatives to succumbing to these impediments and suggests existing and emergent technologies to enhance learning in the DoD's challenging environment. These challenges may be most amenable to computer aided education as that pedagogic technique is effective in asynchronous teaching, in reaching geographically dispersed learners and those with operational obligations that can interrupt training and education at any time and for any duration.

Teaching approaches for DoD students have been conducted via a wide range of educational techniques:

- Didactic lectures
- Small group exercises
- Text book exposition
- Text book exposition
- Model analyses
- Socratic dialogues

Note that most of these imply or require the presence of a tutor or lecturer and some of the earlier cited studies on program efficacy note that the skill and personality of the instructor play a major role in the success of the educational process. Transferring that process into the active-duty or reserve environment for defense personnel suffers from two major debilities: lack of sufficient qualified and engaging instructors as well as inaccessibility of dispersed personnel, all of whom are likely to have immutable operations schedule constraints. In these days of restricted funding, the idea of dramatically increasing the number of instructors or swelling the ranks to ease scheduling limitations are putatively infeasible.

Further, it has been observed that much of the enthusiasm students have for a particular topic, hence its impact on them, is based on their relationship to the instructor. While there is some commonality as to preferences for instructors, there is also some variability; even the most popular professors have some students with whom they are not well matched. At least in major universities where there are classes with several sections, students have the option of finding a professor they like, but the DoD rarely affords this choice to its personnel.

One current community has outlined several major challenges in eLearning [1] and these all appear to be susceptible to any impediment to free and easy information flow. These challenges include the adoption of the Total Learning Architecture (TLA) standard, the pervasive implementation of the Experience Application Program Interface (xAPI), the data management of learner profiles, technology, security, and privacy the provision of effective learning analytics and visualizations, the recognition of accepted competencies and credentialing, the incorporation of learning science for future learning ecosystems, and the establishment of a meaningful DoD/Federal distributed learning policy. None of these seem to be trivial or are cogent remediation strategies assured at this time.

The authors maintain that all of these issues, as well as all issues in education and training have a very large information flow or communication component. Some are directly involve in the training or education; some are more basic and involved in the organizational and procedural aspects of the effort. As the authors are deeply involved in computing, they can also attest that many of these issues are mirrored in computational sciences. Further exacerbating the issues are the incessant disruptions of the social contracts of old which have taken forms like the advent of social media and the ensuing condemnation thereof.

Four thousand years of paper borne literate communication has been observed to have limited the full adoption of the utility of the computer. There are many attempts to convert didactic lectures and written texts to enable Computer Aided Education. The mantra of these attempts might be "Video-tape the lecture." or "Scan the text into ASCII text and post it on-line using HTML." Many of these sites have been unassailably successful and nothing said here should be taken as disparaging both the efforts and the impacts. The authors have observed that humans are inherently primed for and anxious to receive new information. The question raised is: "Are there more effective ways to accomplish the overarching goals.

One example of that dichotomy was America's Army. As is not uncommon, when the military expends funds for necessary defense needs, the civilian population often takes direct advantage of such advances. The case in point is America's Army. [1] It was originally conceived and implemented by a group led by Prof. Mike Zyda at the Naval Postgraduate School in Monterey California. It was supposed to be a recruiting tool, but was mainly just an exercise in computer science for the students. It turned out to be quite popular, not only among the potential recruits, but also with the active duty soldiers who played it and were observed as having sharpened their skills by doing so. (Figure 1) The Army was quick to recognize a good thing and took over the project and it remains a major effort: [2]

Figure 1 Scene from America's Army [3]

The insight here is that the program developed a new and unanticipated way to increase learning by coupling the enchantment young males feel for first person shooter games with actual U.S. Army infantry tactics doctrine. Now an entire industry has sprung up to make this approach useful to the services.

2. The Information Flow Friction Issue

For a long time, perhaps forever, there has been more information available than a person could comprehend. [4] The information obtained by an individual first is limited by the individuals' interest. Then, assimilating this information has been constrained by the technical difficulty of viewing the information. Recent advancements in Information Technology (IT) have drastically changed the amount of information friction to be overcome to obtain information. Realizing the shift in effort requires a different approach to the first step of determining interest and further training on how to most efficiently obtain the information.

2.1 Current Situation

For the last few centuries the human race has been amassing tremendous amounts of information with the store information increasing at exponential rates. [5]

In the mid-20th century many families owned an encyclopedia. It contained the answers to many questions such as "How long is the river Nile?" Once a question was formed it may take several minutes to pull out the correct volume, leaf through the large tome and read the article apropos to the question.

In the 1980's a person walking down a street might see a house for sale and wonder at the asking price. He could return to his house and call the realtor to find the information.

Today, both example questions can be answered in seconds using a smart phone. The speed of the answer is the combination of several technologies including both wireless and backbone networking, storage technology, search technology and hand-held electronics. User interfaces and applications leverage these technologies to make the information virtually instantly available to the person asking the question. The pinnacle of these technologies are

applications such as Facebook, Twitter and thousands of other popular applications running on smart phones and interacting with people seemingly constantly.

The adoption of these technologies has not been instant. Smart phones have been around for about a decade and the other technologies have been available longer. But, Humans take longer to adapt and development of applications and enhancement to the user interfaces have continued to advance. So instantly available information is still a new concept to most people. Some people will never use these technologies. Ask a question of a group of people and it will only occur to a fraction that the answer is on the phone in their pocket or in their hand.

People are still not getting as much information as they could. People living today have been trained to understand information and ask questions using technology from the 20th century and are not taking advantage of the new technology. Problems including asking the wrong questions, not asking questions and having the wrong expectations on what information are attainable.

This new technology has also introduced some inhibitors. One inhibitor is a "helpful" technology to suggest interesting topics to people. One example is customized search results for individuals. Another example is a customized news feed such as Facebook that shows the person the news they want to see based on their previous news browsing. These technologies are "helpful" because they give the results desired by the person. On the other hand, these technologies reduce the person's need to think and influence the questions the person may ask. As a result, the person may not ask the right question. Also, if a person believes that all the relevant information has been provided in their news feed, they will believe things that are not true or complete.

Another inhibitor of information flow is limitations of information flow or censorship of information. An example of this is a country that may prohibit parts of the internet to be view on networks in their nation. So, www.nytimes.com may not be visible in certain nations. Alternately, certain application may be banned: Twitter may be prohibited permanently or just in times of unrest. Of course, there is a lot of information that is private such as financial information and government classified information. The challenge in all of these cases is first to know or suspect its existence and then select the right approach: knowing what you don't know or finding a way to obtain the information anyway.

The last major inhibitor is falsification or "Fake News." Since information dissemination is so easy, someone with malicious or misguided motives can promulgate false information disguised as legitimate data. If a user is not careful, they may believe the falsification.

2.2 Why is this sub-optimal?

The advancements in technology provide a tremendous opportunity for people to know the things they need to know. But people are missing a lot of information by not asking the right questions or assuming they already know what needs to be known. On-going research at the University of Southern California is investigating the inability of High School seniors to formulate rational questions about upcoming career choices. The authors' early thesis is that it is not useful to provide good information to users who not only do not know what to ask, do not know they should be asking any questions

2.3 How would you do it better?

First, people need to be trained in three areas of inhibitors:

1. Get all the information – People should realize the limitations of "helpful" technologies and how to bypass the customized information environment when necessary
2. Recognize censorship and secrecy – People must know or surmise when information exists but is not available to them
3. Assiduously expose "Fake News" – People must have confidence in data and be able to recognize falsifications.

Mitigating the inhibitors improves the information flow, but the person must also be able to ask good questions. This requires a firm grasp of the information that is desired and necessary and the capabilities of the IT system to provide the answer

Additionally, there is room for improvement in user interfaces and the artificial intelligence providing information streams and search results. However, the improvements possible will not provide nearly the dramatic results possible with improvements in human skills listed above

2.4 Who would benefit?

People involved in any endeavor that using information would benefit from knowing more correct information. In the DoD, he entire workforce would benefit. As the defense effort is regarded by this society's leadership as invaluable, he nation as a whole would benefit from the economies and the efficiencies that would flow from this work. One of the major issues here is that the public at large may not see this as a critical issue and be disinclined to either support the effort to improved the situation or to heed the warning about misuse by malefactors or misguided zealots.

2.5 How hard would it be to make the necessary changes?

This is a very hard problem for several reasons:

- Adapting to new technologies takes time. In this case, the thought processes are so complex and the results delayed or invisible make the progress even slower.
- Many of the changes in behavior involve critical thinking. Teaching people critical thinking is possible but very difficult.
- The changes such as asking the right question may not be the easiest or most pleasant alternative to the person in question.

2.6 Critical Thinking Training

Positing the manifest and patent benefits of critical thinking, the question arises as to the possibility of enhancing the skill level in this domain. It must be acknowledged that there are many factors contributing to critical thinking: genetic inclination, childhood experience, formal training, motivation, and natural selection based on trial and error.

Many feel that critical thinking can be taught, but some are skeptical [6]. From the literature, the authors have extracted three major ways in which the improvement of critical thinking is approached: 1) training a rubric to be followed, 2) forming the process by the Socratic method, and 3) using constructivist methods emphasizing self-discovery. Many authors report using combinations of these three approaches. This paper does not have the space to resolve the varying benefits of the differing approaches [7], but will proceed on the assumption that the rubric training approach may be the most applicable to the defense environment, all the while leaving open the use of the other methods as may be appropriate.

Many studies have found that rubric training is effective. One found that the students demonstrated an effective use of the techniques they had learned and effectively displayed it in an encounter during which the researcher did not reveal that they were assessing the subjects' critical thinking skills [8]. One Belgian review of approaches found the multitude of variables made assessing the efficacy of instruction very difficult to adequately quantify in order to allow comparative analysis of the various techniques [9]. A similar study in a professional school setting, nursing, came to virtually the same conclusion [10]. This study is especially germane when looking at the stress, time pressures, and criticality of sound decisions that are common to both combat and the emergency room. These all stress the need to rigorously establish and scrupulously monitor skill parameters in any initiative to improve critical thinking [11].

There may be a preliminary consensus on the steps of the process from which a working model can be extracted [12]. These may be something on the order of:

Collecting data	Reviewing initial conclusions
Categorizing and analyzing	Combining ideas and expanding uses
Using the insights gained	Internalizing the high order concepts

All this activity must be accomplished in the face of the ever-present human tendency to reject logic for a more comforting environment, where wishes and mythology reign [13].

Teaching the critical thinking processes to students has been conducted via a wide range of educational techniques:

Didactic lectures	Text book exposition
Small group exercises	Model analyses
Text book exposition	Socratic dialogues

3. Addressing the Comprehension Issues

A major issue in education is comprehension and retention. A combination of these two effects can be reviewed in the classic Harvard-Smithsonian vide "A Private Universe" [14] in which 21 of 23 Harvard University graduates failed one of both of the following questions:

Why is it hot in the summer and cold in the winter?
and
Why does the moon have phases?

Clearly they had been taught those topics and should have been able to answer the questions, but the data was either not comprehended or it was not retained. One way to improve both Comprehension and retention is to rely on constructivist methods. This approach requires mastery of the subject instead of requiring a shallower rote memorization and ritualistic regurgitation of facts.

3.1 Constructivism, Computers and Comprehension

One of the concerns raised by members of the teaching profession is the specter of its reliance on a charismatic "hero teacher." This is a term with no ostensible consensus definition, but it is not without use [15]. The term is used in this paper to describe a teacher with the following characteristics: 1) a unique ability to motivate and educate otherwise resistant students, 2) a charisma that is part and parcel of that ability, but is ostensibly difficult to emulate, and 3) perhaps, a source of false hope, which is often perceived as more disruptive than efficacious. While the use of the term is often accompanied by hyperbole and pejorative assertions, it still is a topic which may require addressing. The concern is that, if the "hero teacher" is a *sine qua non* for implementation, even attractive results may not be reproducible by other teachers.

In the implementation reported on below, the goals were set as: 1) getting a wider diversity of students interested in the field of science and 2) fostering a culture of design and creativity. This first goal had a subset of goals to achieve. The first goal of the curriculum included sub-goals of increasing the understanding of the scientific approach, instilling basic biology concepts, and developing cooperation skills. The product of this goal was to induce students to develop critical thinking skills and communication skills so they may become more independent thinkers. The second goal was more long-term and professionally oriented; it was to create a culture of design and creativity in education professionals. The authors take as a given that our country will prosper if our citizens and our warfighters become more literate in the areas of Science, Technology, Engineering and Mathematics (STEM). This is not just important for those who want to go to college, but for all who will become the stewards and defenders of this country. This set of goals highlights the dichotomy between education and training.

The intended outcomes are the abilities to generate a population of citizens and a body of service personnel who will be able to think independently and critically, and to creatively solve problems in dynamic environments. The curriculum is designed to allow students, be they adolescents or mid-career service personnel, to be engaged in real life situations and simulations, where they are able to discuss, reason, and solve problems based on evidence they have researched. The students are able to hear different points of view from students at the table, to decide which strategy is best to solve the problem and advance plans to implement that strategy. The concepts that the students not only understand, but have experienced, can be transferred into their everyday lives and professional settings. This can help make our society more perceptive about core issues and have the skill sets to resolve them.

New accessions to the military come from an adolescent population that has grown increasingly inured to the allure of science. There is a certain amount of curiosity that must be present in order for students to remain thinking and engaged in the material [16] . Areas of entertainment, such as video games, movies, apps and music are luring away

student's attention because the game designers have researched what drives students' curiosity. With better constructed and more attractive materials, companies are spending millions on research to keep adolescents' attention. Video game designers work very hard to make video games addictive to their customers [17] . To some, it seems that students are learning more from video games and movies than what they learn in the classroom. This is a dangerous modification of our students' point of view on life and their philosophy of thinking because of the potentially negative impacts of movies and video games [18] To combat this, teachers need to and can improve the production values in the classroom by creating better narratives that resonate with the student's life style and professional environment.

While discussing the authors' approach to implementing the constructivists' approach, the terms framework and scaffolding are central. Educational scaffolding is the process of providing students a series of steps or supports to enable their initial approach to learning a new subject or task. The framework is the author's term for establishing a structure for the critical thinking approach to constructivist problems. In order for the curriculum to be successfully received by the student, these two components need to work in tandem. This is the building of concepts and tasks that will lead to greater and more complex concepts and tasks over time. For example, for a student to create an effective model, they need to be shown in small steps how this is done. Once the teacher feels that the students have mastered this, they can move on to incorporating the model in more complex activities.

In the recent past, educators have often been the deliverers of information as a static product with only one correct answer [19] . The authors hold that this has devalued an important position for education in students' lives. They have personally observed that one of the reasons the students have lost interest in core subjects such as science, literature and math, is because their attention is diverted by non-educators who are better creators of imagery and purveyors of their "reality" than educators. Many are more interested in movies, the internet and video games than they are in school. [20].

The construction of a narrative by a teacher may be analogous to that of an architect constructing a building. The goals of these fields are not much different; in fact, they are similar. John Lautner, the author of "The Purpose of Architecture", says that the purpose of architecture is to improve human life. In architecture, the structure must be as sensible as nature in deriving from a main idea and flowering into a beautiful entity [21] . Educators, in the DoD or in civilian institutions, all want, and sometimes need, to improve student's lives. The constructivist theory [22] asserts that students construct their own knowledge of the world through the meaning from their experience [23]. By comparison, architects use the raw materials such as wood, concrete and steel to create masterful works of art. Educators can apply an equivalent framework to their lessons in the classroom. The framework is the collection and organization of the content and concepts that are designed in an organized way for the students to learn or to master. The raw materials for an educator are ideas that make up concepts and systems of concepts. Many teachers have not been trained how to teach concepts or allow their students to access these raw materials on their own [24]. Fortunately, there is a way to construct ideas into concepts and finally into systems of concepts through questioning. These questions and the answers to the questions become analogous to the raw materials available to architects enabling them create their works of art.

3.2 Improved Information Flows in the DoD

As young NCO's and Commissioned Officers come to the end of their first service obligation, career choices need to be made and the authors believe that those staying in the service will increasingly need the kinds of education that can optimally be implemented using constructivist methods. The authors have presented a functioning example of how the constructivist theory can be implemented better by providing the recipients of the education with a framework to assist their transition into a constructivist environment. The need for "thinking" military leadership has long been recognized, even in some establishments as reputed for blind obedience, as the World War II Wehrmacht [25].

The authors assert from personal experience that these methods are extensible into the post secondary education environment. While many of the military recruits come straight from high school, pressure to pursue collegiate education is very real for active duty personnel, even mid-level NCO's. Of course, the DoD is responsible for the service academies and the Reserve Officer Training Corps at many major US universities. Further, there are a significant number of personnel on active duty who are seeking associate or bachelor's degrees at civilian universities, over which the military has some control, but very little. Still the lessons learned from this

implementation of constructivism could be fostered by any number of directives or inducements to the educational entities involved. Due to operational commitments, all these educational activities will have to be designed so as to not disrupt the critical skills training, in which all service people need to continue. Following collegiate endeavors are the postgraduate opportunities offered at the various service schools and staff colleges. It is at this level that the approaches begin to include many non-didactic forms: business schools' case study method, law schools' Socratic method and masters and PhD research studies. Prescribing and designing appropriate constructivist curricula for these levels is clearly possible, but beyond the scope of this paper.

At career's end, there are whole ranges of transition activities that may benefit from incorporation of constructivist techniques similar to those discussed here. The educational topics that would be amenable to this approach are virtually ubiquitous. A professional more used to didactic education may at first find it less comfortable, but with experience, it becomes easier to see how for them to structure the subject matter to make it accessible to the students via constructivist approaches. The topics of leadership, strategy, international relations, planning, logistics, intelligence and human relations are all well suited to the approach outlined above. Even edging into the adjacent field of training, one could see the constructivist approach as being a new tool in enhancing skills in mission planning, after action assessment and reporting, management, and training implementation.

As to a second issue, the current public education system was originally designed to facilitate the transition of agricultural workers into the urban industrial environment. Enlisted personnel were expected to know how to read and write and follow orders; officers were expected to be more erudite and civilly sophisticated, but it could be said that raw courage and unflinching obedience were the hallmarks of a good military man. But times have changed and are continuing to change. Changes that used to take centuries are now occurring in years. The need to walk lock-step in formations in the face of withering fire has given way to the individual service member having to have the diplomatic skills of an ambassador and the technical mastery of an engineer. The need to learn how to think [26], and not just what to think, is greater now than ever and will likely be even more needed in the future. A benefit of the architected features of this approach is the curriculum can be easily adjusted to meet the needs of the DoD personnel that it is to serve, both in level of concept sophistication and need for structure. It is also amenable to the "serious games" approach as was discussed in the America's Army project.

A third issue is similarly amenable to the implications of this work. Education can be said to be founded on communication, wherein the educator intends to deliver his knowledge to others. The insights gained from this communication process should be applicable to other communication efforts. Military history is replete with the importance for communications to the Warfighter. Be it intelligence, operations orders, status reports, or other necessary communications, the use of constructivist techniques, like the "Five E's" or the knowledge that some perceive better visually than orally, may make a critical difference at a vital juncture. These processes, by their very nature, encourage the students to think about the way they think: meta-cognition. Critical thinking and meta-cognitive skills can be taught and have been shown to produce beneficial results. [27]

3.3 Computer Contributions to Flow Improvement

There are of course, many pressures on emerging simulation technology. In a separate paper at this conference, two computational advances were identified and explicated: Deep Learning and Quantum Computing [28]. That paper focuses on the need for improved data management for huge amounts of data and the application of Deep Learning to effectively reduce this data to useable insights for the user. As the data's magnitude requires computational power in excess of that which would be easily obtainable from current digital machines, it further argues the need for a new computation paradigm and suggest the D-Wave Quantum Annealers now on the market as an initial introduction into that technology.

Two of the challenges that face the services today are decreasing funding and accelerating operations schedules. Yet the need for continuing and improving education at all career levels is assumed by the authors. To address this conundrum, the authors suggest the implementation of the basic techniques laid out above using centralized simulations, delivered on-line, and making use of emerging capabilities to replace live humans with computer generated virtual human avatars. The simulated battlefield capabilities have already shown their potential abilities to act as training devices [29] to operate transcontinentally [30]. If the frictions identified earlier are to be addressed, then this type of high-bandwidth, secure and accessible network will be required for the warfighters to profit from it. Many virtual reality programs will similarly not admit of latencies of longer than 500 milliseconds, as

any longer delay produces artifacts in the simulation that are so disruptive to the user participants as to destroy the illusion of live conversation. This issue has been addressed in the work cited above and is graphically represented in Figure 2 below.

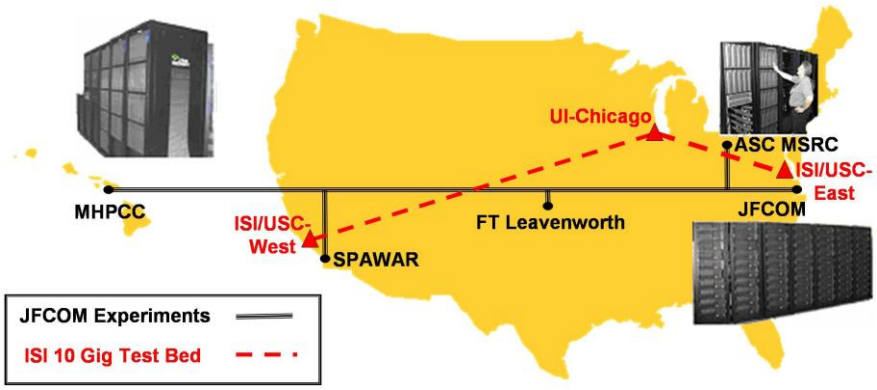

Figure 2 Experimentation System and ISI 10 Gig/Sec. Test Bed

This allowed the system to engage the users effectively [31]. The authors assert that, at a very reasonable cost, defense contractors could modify existing battlefield simulation capabilities to emulate any period of history and set the action in any terrain conceivable.

This raises the daunting issues of fiscal constraints and travel issues dictated by the dispersion of personnel. The development of virtual human avatars with emerging capabilities responds to both of these issues. Already, this technique has proven effective in the treatment of PTSD sufferers [32] (Reger, et al., 2015), and new technologies are rapidly extending the capabilities of the avatars [33] (Nye, et al., 2017). This could easily provide a mentor around the clock.

In the authors' experience any paradigmatic change can be difficult, threatening and disruptive. Looking at the changes necessary to implement the methods outlined above and considering the stresses on the DoD today, the question may arise concerning the plausibility of successful adoption. They have experience with the instructional capabilities of large scale intercontinentally distributed simulations. They are currently engaged in several project making increasingly seamless use of computer generated avatar virtual humans [34](ICT, 2015b) to conduct real-time, life-like conversations at a level that many users have shown a proclivity toward "speaking" with an avatar over a live human being on-line . These all support the notion that making education available to active duty and reserve personnel could be effectively and economically implemented for the DoD.

4. Conclusions

This paper has presented the thesis that Information flow is critical to the education and training of the personnel of the uniformed services of the US Department of Defense. While high performance computers and communication systems have greatly enhanced the service personnel capabilities to move information, not enough has been done to ameliorate the burgeoning data flows that face the warfighter. Now his has been even further exacerbated by the intrusions of several factors of friction that inhibit the flow, comprehension and retention of the data required.

The authors laid out observations and characterization of the negatives caused by both this glut and by the frictions impeding the flows. This has manifestly interfered with both retention and comprehension. Even the best and brightest are not immune from these issues.

Constructivist approaches hold promise in addressing many of the issues mentioned herein and the promise of better performance from the new quantum computers will further reduce information flow frictions, improving the otherwise daunting task of training and education the US Armed Forces.

5. ACKNOWLEDGEMENTS

MentorPal is supported by grants from the Office of Naval Research from the ONR STEM Program: Mentor PAL: Growing STEM Pipelines with Personalized Dialogs with Virtual STEM Professionals, N00014-16-1-2820. The statements and views expressed in this paper are the views of the authors alone and do not represent the views of the Office of Naval Research or the US Government.

6. References

[1] Davis, D.M. Private conversation with *Prof. Michael Zyda* at the Viterbi School of Engineering, University of Southern California, Los Angeles. 2012

[2] U.S. Army. *America's Army*, retrieved from the Internet on 12 July 2018, from a site at URL: http://www.americasarmy.com/

[3] America's Army Screen Shots, retrieved from the Internet on 14 July 2018, from a site at URL: http://www.aao.parba.cz/img/screen_2b.gif

[4] iFEST 2018, iFEST, The Future Learning Ecosystem, Advanced Distributed Learning, retrieved from the internet on 23 June, 2018, from: https://adlnet.gov/news/ifest-2018

[5] REMO Software. *History of Storage from Cave Paintings to Electrons (Infographic)*., retrieved 25 June 2018 from: https://www.remosoftware.com/info/history-of-storage-from-cave-paintings-to-electrons.

[6] Willingham, D. T. (2007). critical thinking. *American Educator*, 31(3), 8-19.

[7] Pithers, R. T., & Soden, R. (2000). Critical Thinking in Education: A review. Educational Research, 42(3), 237

[8] Lehman, D. R., & Nisbett, R. E. (1990). A Longitudinal Study of the Effects of Undergraduate Training on Reason

[9] Tiruneh, D. T., Verburgh, A., & Elen, J. (2014). Effectiveness of critical thinking instruction in higher education: A systematic review of intervention studies. *Higher Education Studies*, 4(1), 1.

[10] Carter, A. G., Creedy, D. K., & Sidebotham, M. (2016). Efficacy of Teaching Methods used to Develop critical Thinking in Nursing and Midwifery Undergraduate Students: A Systematic Review of the Literature. *Nurse Education Today*, 40, 209-218.

[11] Halpern, D. F. (2002). Thought and Knowledge: An Introduction to critical thinking. Routledge.

[12] Lai, E. R. (2011). Critical thinking: A literature review. *Pearson's Research Reports*, 6, 40-41.

[13] Ariely, D. (2008). *Predictably Irrational* (p. 20). New York: HarperCollins.

[14] Annenberg Learner, *A Private Universe*, The Harvard-Smithsonian Center for Astrophysics, retrieved from the Internet on 02 July 2018 from: https://www.learner.org/resources/series28.html

[15] Ayers, W. A Teacher Ain't Nothin; but a Hero: Teachers and Teaching in Film, in *Images of Schoolteachers in America.* Joseph, Pamela Bolotin, and Gail E. Burnaford, eds. Routledge, 2000.

[16] Willingham, D. T. *Why don't students like school?: A cognitive scientist answers questions about how the mind works and what it means for the classroom.* John Wiley & Sons. 2009

[17] Harrigan, K. A., Collins, K., Dixon, M. J., & Fugelsang, J. . Addictive gameplay: what casual game designers can learn from slot machine research. In *Proceedings of the International Academic Conference on the Future of Game Design and Technology* (pp. 127-133). ACM. 2010, May.

[18] Tompkins, A. (2003). The Psychological Effects of Violent Media on Children. Psych Journal, 14.

[19] Schmoker, M., & Marzano, R. J. . Realizing the promise of standards-based education. *Educational Leadership*, *56*, 17-21. 1999

[20] Gallagher, Michael D., , *Entertainment Software Association Essential Facts Report*, retrieved from the internet on 06 April 17 from: http://www.theesa.com/wp-content/uploads/2015/04/ESA-Essential-Facts-2015.pdf. 2015

[21] Lautner, John, . The Purpose of Architecture, The John Lautner Institute, retrieved from the internet on 06 April 2017, from: http://www.johnlautner.org/wp/?p=710 2011

[22] Jonassen, D. H. . Evaluating Constructivistic Learning. Constructivism and the Technology of Instruction: A Conversation, 137-148. 1992

[23] Hein, George. . Constructivist learning theory. *Institute for Inquiry*. Retrieved from the internet on 15 April 2017, from: https://www.exploratorium.edu/education/ifi/constructivist-learning. 1991

[24] Torff, B., & Sessions, D. N. . Principals' Perceptions of the Causes of Teacher Ineffectiveness. *Journal of Educational Psychology*, 97(4), 530. 2005

[25] Tetlock P. E., & Gardner, D. (2015). *Superforecasting: The Art and Science of Prediction*. Broadway Books, The Crown Publishing Group, New York, NY. 215-229

[26] Davis, L. K., Curiel, J., & Davis, D. M., (2010), "HITL and Metacognition: Self Analysis and Leadership Enhancement During Simulations", in the Proceedings of the *SISO Fall 2010Simulation Interoperability Workshop*, Orlando, Florida

[27] Lehman, D. R., & Nisbett, R. E. (1990). A Longitudinal Study of the Effects of Undergraduate Training on Reasoning. *Developmental Psychology*, 26, 431-442.

[28] Yao, K-T., Davis, D. M., Liu, J. J., & Kaimakis, N. J.. (2018, Pending). "New Technologies to Enhance Computer Generated Interactive Virtual Humans ". In the Proceedings of the *SISO Fall Simulation Innovation Workshop*, Orlando, Florida:SISO

[29] Lucas, R., & Davis, D., "Joint Experimentation on Scalable Parallel Processors," (2003), in the *Proceedings of the Interservice/Industry Simulation, Training and Education Conference*, Orlando, Florida, 2003

[30] Gottschalk, T. D., Yao, K-T., Wagenbreth, G. & Davis, D. M., (2010), "Distributed and Interactive Simulations Operating at Large Scale for Transcontinental Experimentation", in the *Proceedings of the IEEE/ACM Distributed Simulations and Real Time Applications 2010 Conference*, Fairfax, Virginia

[31] ICT, (2015a), *Video of SimCoach in action*. SimCoach Project, Institute for Creative Technologies, University of Southern California, Los Angeles, California, and it was Retrieved 27 June from https://www.youtube.com/watch?v=2bsMESwBeyg&index=14&list=PLBF277FAE78E8CB39

[32] Reger, G. M., Rizzo, A. A., & Gahm, G. A. (). Initial Development and Dissemination of Virtual Reality Exposure Therapy for Combat-Related PTSD. *In Future Directions in Post-Traumatic Stress Disorder* (pp. 289-302). Springer US. 2015

[33] Nye, B., Swartout, W., Campbell, J., Krishnamachari, M., Kaimakis, N. and Davis, D. MentorPal: Interactive Virtual Mentors Based on Real -Life STEM Professionals . in the *Proceedings of the Interservice/Industry Simulation, Training and Education Conference*, Orlando, Florida, 2017

[34] ICT, (). *Selected Slides from presentation to the Army Research Laboratory.* http://www.hpc-educ.org/AFIT-Init/Materials/Slides/VH-or-Voice-or-StaticImage.pdf. 2015

Authors' Biographies

MARK C. DAVIS, PH.D. is currently retired after careers in the US Navy and as a computer design engineer for both IBM and Lenovo. Rising to the level of Distinguished Engineer at Lenovo, he was responsible for the design of laptop computer cross-disciplinary technology, including PC architecture, embedded systems, open source and virtualization. Previous work was with IBM in the areas of software development and architecture involving security, storage and virtualization. Dr. Davis has been granted well over fifty patents that were filed during his service at both companies. He is a graduate of the Duke University NROTC program and was commissioned as an Ensign, attended nuclear power school, and served as an Submarine Officer for twelve years, including one duty tour as a classroom instructor. He left the service as a Lieutenant Commander to pursue a PhD. Mark holds a BSEE degree from Duke University and a PhD in Computer Science from the University of North Carolina, where his advisor was Professor Fredrick P. Books.

DAN M. DAVIS is now a consultant for the University of Southern California, focusing on large-scale distributed DoD training, education and avatar mentors. Pre-retirement, he was the Director of USC's JESPP project for JFCOM for a decade. As the Assistant Director of the Center for Advanced Computing Research at Caltech, he managed Synthetic Forces Express, bringing HPC to DoD simulations. Prior experience includes serving as a Director at the Maui High Performance Computing Center and as a Software Engineer at the Jet Propulsion Laboratory and Martin Marietta. He has served as the Chairman of the Coalition of Academic Supercomputing Centers and has taught at the undergraduate and graduate levels. As early as 1971, Dan was writing programs in FORTRAN on one of Seymour Cray's CDC 6500's. He saw duty in Vietnam as a USMC Cryptologist and retired as a Commander, Cryptologic Specialty, U.S.N.R. He received B.A. and J.D. degrees from the University of Colorado in Boulder.