Employing Interactive Multimedia Instruction in Military Science Education at the U.S. Military Academy

Christopher M. Farrell
Operations Research Center of Excellence
Department of Mathematical Sciences
United States Military Academy
West Point, New York
Chris.Farrell@usma.edu

William K. Klimack
Department of Systems Engineering
United States Military Academy
West Point, New York
William.Klimack@usma.edu

Carl R. Jacquet
Department of Military Instruction
United States Military Academy
West Point, New York
Carl.Jacquet@usma.edu

ABSTRACT

In line with Army Transformation, the United States Military Academy at West Point is revolutionizing the way that tomorrow's leaders learn and are taught. Central to this initiative is the employment of emerging technologies to supplement traditional classroom instruction. This includes Interactive Multimedia Instruction (IMI) to reinforce learning and to evaluate cadet proficiency. The overall goal is to expose cadets to courseware that fully engages them, both cognitively and emotionally. This is being realized through a distance learning (DL) proof of principle incorporating intermediate desktop simulation. The web-based IMI affords cadets access to high-quality course materials independent of the classroom environment and its rigid time constraints. Cadets can readily negotiate the courseware, focusing where they feel most in need of reinforcement. This paper illustrates the challenges of experimentation in this context. An examination of the hypotheses that support a study of IMI effectiveness in educating cadets on the tasks that support land navigation is conducted. Finally, results and analyses are discussed. Specifically, IMI is assessed as effective in the knowledge transference of the tasks that support tactical map reading and land navigation. Additionally, the Academy has continued to expand its use of commercial-off-the-shelf (COTS) and government-off-the-shelf (GOTS) software in military science courses. These products have been employed as practical exercise vehicles, providing an environment in which cadets can develop and refine skills and tactical principles germane to the core military science program. Modifications made to America's Army™ ("The Army Game") target individual and collective tasks that are part of the fourth class curriculum. PC-based simulation scenarios have also been tailored for executing dismounted force-on-force operations. The result is excited and motivated cadets who take ownership of their military development, in terms of what they study, when they study it, and how both cadets and instructors receive feedback on performance.

ABOUT THE AUTHORS

Major Christopher M. Farrell, M.S. Instructor in the Department of Mathematical Sciences and analyst in the Operations Research Center of Excellence at the United States Military Academy (USMA), West Point, New York. Major Farrell earned a B.S. in Systems Engineering (Operations Research) from USMA in 1991 and did his graduate work in Operations Research at Virginia Tech in Blacksburg, Virginia. He is a member of the American Mathematical Society, Society for Industrial and Applied Mathematics, Institute for Operations Research and the Management Sciences (INFORMS), Aircraft Owners and Pilots Association, and the Army Aviation Association of America. Major Farrell is a senior rated Army aviator with over 1,000 flight hours in fixed and rotary wing aircraft. He has served in command and staff positions with AH-64 Apache attack aviation units of the 101st Airborne Division (Air Assault), Fort Campbell, Kentucky and 6th Cavalry Brigade (Air Combat) in the Republic of Korea. His research interests include modeling and simulation initiatives that support conflict risk assessment and mitigation in air transportation networks. Major Farrell will next be assigned as a Readiness Analyst to the U.S. Army Training and Doctrine Command, Fort Monroe, Virginia.

Colonel William K. Klimack, Ph.D. Associate Professor in the Department of Systems Engineering and Director of the Operations Research Center of Excellence at USMA. Colonel Klimack received a Ph.D. in Operations Research from the Air Force Institute of Technology, holds a M.S. in Applied Mathematics from Johns Hopkins University, a Masters in Military Art and Science from the U.S. Army Command and General Staff College, and a B.S. in Chemical Engineering from Lehigh University. He serves on the Executive Council of the Military Applications Society of the Institute for Operations Research and the Management Sciences (INFORMS), on the Science Advisory Board of the Explorers Club, and on the Board of Directors of the National Speleological Society. He is a Fellow of the Explorers Club and the Royal Geographical Society. He is also a member of the International Council on Systems Engineering, the Decision Analysis Society of INFORMS, and the American Society for Engineering Education. As an Infantry officer, he has served at every level from platoon to Army and in five divisions.

Captain Carl R. Jacquet, M.S. Director of the Warfighting Simulation Center and a course director in the Department of Military Instruction, USMA. He received a M.S. in Interactive Simulations and Training Systems from the University of Central Florida in 2002 and a B.S. from USMA in 1993. He is an armor officer qualified on M1A1 tanks and is a member of the United States Armor Association. He has served in command and staff positions in tank battalions and armor brigades in both Germany and Fort Riley, Kansas. His research interests include the effectiveness of virtual reality training and PC-based desktop simulation.

Employing Interactive Multimedia Instruction in Military Science Education at the U.S. Military Academy

Christopher M. Farrell
Operations Research Center of Excellence
Department of Mathematical Sciences
United States Military Academy
West Point, New York
Chris.Farrell@usma.edu

William K. Klimack
Department of Systems Engineering
United States Military Academy
West Point, New York
William.Klimack@usma.edu

Carl R. Jacquet
Department of Military Instruction
United States Military Academy
West Point, New York
Carl.Jacquet@usma.edu

A DISTANCE LEARNING PROOF OF PRINCIPLE

Under the research and studies partnership between the Assistant Secretary of the Army for Acquisition, Logistics and Technology and the United States Military Academy (USMA) at West Point, Program Manager-Soldier Systems (PM-Soldier Systems) at Ft. Belvoir, Virginia and various academic departments at USMA have collaborated on numerous research projects over the past several years.

In 2001, the Operations Research Center of Excellence (ORCEN) and the Department of Military Instruction (DMI) at USMA laid the foundation for a multiyear study of the utility of web-based instruction in military science education at the Academy. This work became the catalyst for the first-ever integrated application of distance learning (DL) in cadet education at West Point. The scope of the study was further refined, focusing specifically on the effectiveness of interactive multimedia instruction (IMI) in the context of a DL pilot program at USMA.

Fourth Class Military Science Education

The first-year military science course, MS102 – Ground Maneuver Warfare I, was identified as the test bed for the DL pilot. MS102 is the first of four required military science courses at USMA. It is a 35-hour course consisting of 27 lessons focusing on essential warfighting principles that provide the basis for the cadets' military development while at USMA, as well as their technical and tactical competencies as future commissioned officers. The scope of the course covers numerous topics to include map reading and land navigation, ground maneuver theory and doctrine at the infantry platoon level and below, elements of combat power, principles of war, and the factors of METT-TC. In addition to traditional classroom instruction by members of the USMA faculty, guest lectures by distinguished military figures and warfighting readings are distributed throughout the course. The culminating event of Military Intersession, the two-week period when cadets traditionally study only military science, is a week of computer simulation. During a series of dismounted engagements, fourth class cadets employ the tactical and technical knowledge acquired over the previous week in both offensive and defensive operations, executed synchronously utilizing networked intermediate desktop simulation tools.

Employment of Interactive Multimedia in the Courseware

In order to gauge the effectiveness of IMI in the DL pilot, courseware was required. The ORCEN and DMI utilized contracting support and other resources provided by PM-Soldier Systems to storyboard and build relevant IMI courseware to the Academy's specifications. It was decided that the IMI should supplement the existing materials for a specific portion of the course. Hence, the IMI would strictly include the tasks that support map reading and land navigation as covered over several lesson blocks. Specifically, the lessons covered by the IMI included (1) Maps and their Properties, (2) Operational Terms and Symbols, (3) Terrain Features, Elevation and Distance, and (4) Azimuth and Direction.

Some existing courseware was utilized as the foundation for the DL program of instruction. A crosswalk of this courseware with the Student Performance Objectives (SPOs) was conducted for each lesson. Where appropriate, the courseware was modified and expanded accordingly to insure complete coverage of all MS102 SPOs for map reading and land navigation. The resulting tasks were presented in three corresponding IMI modules. They were (1) Maps and their Properties, (2) Operational Terms and Graphics, and (3) Determine Azimuth.

Representation of Various IMI Levels

In order to establish a baseline against which to test IMI effectiveness, cadets fell into one of three groups for each lesson module – control group, level 2 IMI, and level 3 IMI. A graphical representation of the interaction between student and courseware for IMI levels 2 and 3 are found at Figures 1 and 2, respectively.

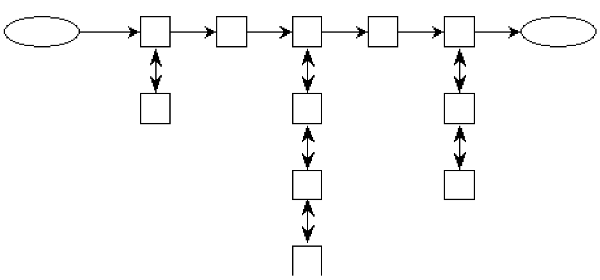

Figure 1. Student-IMI Interaction: Level 2

Level 2 IMI is characterized by a two-way instructional flow in which interactive courseware prompts the student to respond to lesson cues. Level 2 IMI has medium simulation presentation within which basic branching is allowed, and student responses are tracked for branching decisions as well as performance (e.g. pass/fail scenarios). The training taxonomy is in the cognitive domain using the advanced knowledge category of exercise solving. This differs from the rote learning seen in level 1 IMI. In that case, the student learns largely through memorization and restatement of the material. However, level 2 IMI may require the student to memorize a series of steps or a procedure. Level 2 IMI doesn't necessarily guarantee that the student will understand the motivation behind the exercise. At a minimum, though, the student will know that by learning the required steps, he or she will get the correct answers on an evaluation. Generally speaking, level 2 IMI will present a choice or question and, upon student input, immediate feedback is given in the form of the correct answer(s) and/or additional information. In the case of the USMA IMI product, cadets had virtually total freedom to navigate the courseware, going back to previous material as many times as desired to reinforce the concepts. The only tasks they were required to complete were to provide demographic data, take the pre- and post-tests, as appropriate, and fill out the electronic validation surveys at the end of each lesson. This was done after negotiating a given IMI lesson, in total, at least once.

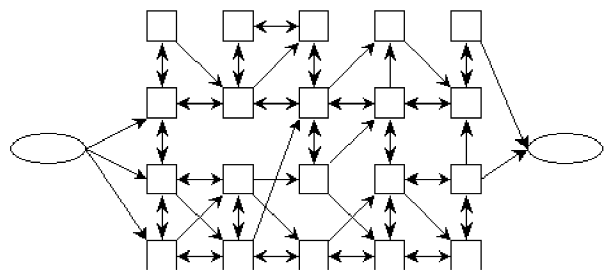

Figure 2. Student-IMI Interaction: Level 3

Level 3 IMI has essentially a one-way instructional flow commensurate with that of level 1 IMI. However, in level 3, it is in the opposite direction – student to courseware. The IMI does very little prompting but rather provides information that the student will later apply to solve a problem. It has high simulation presentation and involves the recall of more complex information than the previous two IMI levels. The user also has an increased level of control over the courseware. Multiple software branches 2-3 levels up support remediation. Emulations and simulations are an integral part of this level. The training taxonomy is in the cognitive domain using problem solving. Problem solving is a higher form of learning whereby students take facts, rules and principles and apply them to an evaluated scenario.

Level 4 IMI has real-time or *full* (virtual) simulation. The instructional flow is essentially one-way, in the same direction as that of level 3 IMI. However, the interactive courseware does no prompting whatsoever. Errors can be compounded, and feedback and remediation are not given in the middle of the lesson, only at the end. The training taxonomy is in the cognitive domain using analysis. There is a high degree of interactivity and level of presentation. It has extensive branching, perhaps even 4 or more levels up. However, in terms of sophistication of the software, it is short of artificial intelligence. Level 4 IMI was introduced into the DL pilot and the resulting experiment by using the "America's Army" desktop simulation as described in subsequent sections. Level 4 IMI is the most demanding for the student. The courseware depends largely on the student to provide inputs and real-time feedback is given. Whereas IMI levels 2 and 3 were introduced via the lesson modules, level 4 IMI was employed as a practical exercise vehicle by which the cadets' proficiency in map reading and land navigation was evaluated.

Level 1 IMI, commonly referred to as "page turning," was not evaluated in this experiment, as all available resources were expended to give cadets the most multimedia-rich course materials possible.

Use of "America's Army"

In previous years, the software used for dismounted simulation exercises was the commercially available Delta Force game variants. Over the course of two intersessions, the developer modified the software based on input by cadets. Modifications included, among other things, introduction of digital maps into Delta Force 2, making it more representative of what a Land Warrior-equipped soldier might see. The goal of this effort was to make the resulting software more realistic and doctrinally correct.

During Military Intersession 2003, the transition was made to "America's Army: Operations", commonly referred to as "The Army Game." "America's Army" is a government-off-the-shelf (GOTS) product conceived and managed by the Office of Economic and Manpower Analysis (OEMA) at USMA. The original purpose of the software was to improve recruiting and retention by educating the youth of America on the realities of being a soldier. This includes various aspects of training, such as entry level (basic training) and Airborne School at Fort Benning, Georgia, to name but a few. Over the course of a given person's progression through the various stages of the game, certain skills and capabilities are acquired. This translates to a virtual soldier's combat effectiveness when he or she is engaged in force-on-force scenarios.

The ORCEN and DMI were the catalysts behind the first use of "America's Army" as a training tool for individual and collective training. This was accomplished through direct collaboration with both OEMA and the development team for software modifications. Specifically, a "virtual" land navigation course in "America's Army" was created for USMA. The goal for this new scenario was that it would serve as a practical exercise vehicle by which the fourth class cadets' skills could be evaluated prior to executing a record land navigation course during Cadet Field Training in their second summer at the Academy.

THE STUDY

Statistical analysis was conducted on cadet performance scores in web-based pre- and post-tests and on elapsed times – both aggregate and between points – on the "America's Army" land navigation course.

There were 1,089 students from the USMA Class of 2006 who were enrolled in MS102. The goal for cadets and instructors alike was to have them exposed to all three IMI levels at some point in the course. As such, cadets were broken out into one of three courses, each containing the three lesson modules presented with varying levels of interactivity. Evaluation of the effectiveness of the various IMI levels was gauged by examining performance of the individual cadets in the pre- and post-test exams for each lesson. The layout of the level 2 and 3 IMI lessons consisted of a pre-test, the lesson module itself containing one or more "firefights," or checks on learning, and a post-test. Online validation questionnaires were completed at the close of each IMI lesson and data collected on individual cadets' opinions on various aspects of the IMI lesson.

The control group completed the written programmed text and then went to the DL courseware, completing only the post-test exam. The level 2 and level 3 groups for each lesson also had access to the programmed text. This was a strict requirement imposed by the MS102 course director, primarily to insure that no subpopulation of cadets achieved a marked advantage over others in the course when it came to graded exercises. At the outset, this action was approved and was deemed to not affect the experimental results at all, as the course materials that *every* subject had access to were homogeneous. This also insured that the IMI cadets got the same information as the control group prior to executing the appropriate IMI lesson.

Each post-test was a *gated* event, such that each cadet needed to achieve a passing score of 70% or better before they could move on to the next lesson. This was true for both the control group and the students doing a given IMI module. However, in order to insure that the most unbiased scores were examined, only the results of the first test were considered in the analysis. This was also true of cases where a given cadet did multiple iterations of the virtual land navigation course. However, performance data were captured for all cadets, to include scores on each post-test attempt, times for each run through the land navigation course, web pages "hit" and duration, among others.

To insure that each cadet completed the correct lesson modules, they were laid out in a manner that was effectively unidirectional. Even though cadets could review lessons within their respective courses thus exercising the flexibility afforded by the IMI, they could not do a lesson in the wrong IMI level, or in multiple IMI levels. Each course can therefore be described as "one way in, one way out." Table 1 shows the three courses, by lesson and IMI level, for which each member of the Class of 2006 was aligned with one course only. Lessons in subsequent tables are labeled as "MAP", "OTG", and "DA." These stand for Maps & their Properties, Operational Terms & Graphics, and Determine Azimuth, respectively. Each of the three courses – "WP 1", "WP 2" and "WP 3" – contains the lessons, as described above, in one of the various IMI levels. "CG" stands for Control Group which has no IMI and is post-test only, "2" is for level 2 IMI, and "3" represents level 3 IMI.

Hypotheses

The underlying assertion in this study is that IMI is at least as effective or more so than traditional methods of teaching cadets the tasks that support map reading and land navigation. This theory will be evaluated through a series of supporting hypothesis tests. The first hypothesis (H1) is that cadets who executed the IMI modules (level 2 or level 3) would perform better in the post-test than they did in the pre-test. This is consistent with the findings of Merino and Abel, 2003, who studied the effectiveness of computer-mediated accounting tutorials for fourth- and fifth-year engineering students.

H2, the second hypothesis, states that cadets who did the IMI courseware will perform better on the post-tests than those cadets in the control group who prepared for class strictly by doing the programmed text.

The third hypothesis, H3, asserts that, due to the nature of the information and techniques associated with map reading and land navigation, level 2 IMI may provide the most appropriate level of multimedia presentation required to evoke better cadet performance in this area as indicated by better post-test scores.

H4, the fourth hypothesis, states that cadets executing the course with the most multimedia-rich IMI lesson for basic map reading would have a greater grasp of the fundamentals of land navigation such that they would perform better on the practical exercise in "America's Army."

Table 1. Course Breakdown by Lesson and IMI Level

Course	**Lesson**	**IMI Level**		
		CG	**2**	**3**
WP 1	**MAP**			X
	OTG		X	
	DA	X		
WP 2	**MAP**		X	
	OTG	X		
	DA			X
WP 3	**MAP**	X		
	OTG		X	
	DA		X	

Corollary to this is the fifth hypothesis (H5) which is that cadets who have access to the richest Basic Map IMI content will have a better inherent understanding of land navigation fundamentals such as terrain association so that they would find the most challenging point on the land navigation practicum more quickly than those in the other two courses. Busciglio and Teplitzky, 1994, reported that spatial tests, to include a map test, were positively related to military orienteering performance. Both the Basic Map pre- and post-tests have similar spatial elements and, therefore, are arguably the most relevant aspect of the IMI courseware as it pertains to practical land navigation, to include a virtual land navigation course. Therefore, a point was placed on the course that would require cadets to use terrain association more than simply dead reckoning, where cadets apply their pace count over a given distance and compass heading, or azimuth.

The final hypothesis, H6, states that cadets who were identified as above average performers in the IMI also did better on the virtual land navigation course than those who were tabbed as below average performers. Cut-off scores were established as being equal to or greater than _-standard deviation above and below the sample mean post-test scores for above average and below average performers, respectively.

RESULTS

Data were captured electronically for the on-line exams by the learning management system collocated with the servers and courseware. For all evaluations, to include the land navigation course, cadets were required to do as many iterations as needed to achieve a passing score. However, they were allowed to do as many as they wanted until they were satisfied with their performance and were comfortable that they had sufficiently learned the material.

Though all performance data were collected, only the first iteration was measured. This course of action was determined to likely yield the purest data that could be attributed solely to the quality and effectiveness of the IMI courseware. Subsequent test scores might be tainted by improvements in performance based on cadets having seen the questions one or more times before, as well as feedback received on questions previously gotten wrong, and other factors.

Table 2 contains pre-test data for all cadets who executed the levels 2 and 3 IMI. Table 3 contains post-test data, by lesson and IMI level, for all cadets in the study. There is no level 3 IMI data for the Operational Terms and Graphics (OTG) lesson. The nature of that task is largely rote memorization and symbol recognition. Therefore, we decided to develop that lesson in only one IMI level.

Table 2. Pre-test Data

Lesson	Statistics	IMI Level	
		2	3
MAP	Mean	0.7287	0.7216
	Std. Dev.	0.0814	0.0853
	Std. Error	0.0044	0.0045
OTG	Mean	0.8213	
	Std. Dev.	0.1058	
	Std. Error	0.004	
DA	Mean	0.8401	0.8289
	Std. Dev.	0.1398	0.1415
	Std. Error	0.0076	0.008

Table 4 displays time data from the land navigation practical exercise in “America’s Army.”

Table 3. Post-test Data

Lesson	Statistics	IMI Level		
		CG	2	3
MAP	Mean	0.8058	0.8523	0.8378
	Std. Dev.	0.0817	0.0777	0.0767
	Std. Error	0.0044	0.0043	0.0041
OTG	Mean	0.6470	0.8586	
	Std. Dev.	0.2153	0.0833	
	Std. Error	0.0120	0.0032	
DA	Mean	0.8336	0.9225	0.9003
	Std. Dev.	0.1366	0.0852	0.1033
	Std. Error	0.0075	0.0047	0.0058

These data are broken out by each of the three MS102 course combinations, for which a given cadet falls into one and only one course.

Table 4. Elapsed Times from Land Navigation Practical Exercise (MM:SS)

Course	Sample Statistics		
	Mean	Std. Dev.	Std. Error
WP 1	8:32	3:19	00:14
WP 2	9:13	3:12	00:14
WP 3	8:34	3:48	00:14

Table 5 contains time statistics between points 3 and 4 on the six-point compass line course for each of the three MS102 course laydowns. This section of the land navigation course was particularly challenging for the cadets due to the fact that there was substantial mountainous terrain between the two points. If the cadets applied only dead reckoning, whereby one plots and follows a given azimuth while utilizing one’s pace count, then they might lose their fix on point 4. This would occur at about the midpoint of a line between the two adjacent points when the virtual cadet would be unable to scale the terrain on his or her intended course. Therefore, in order to quickly and correctly find the point, the cadets needed to utilize terrain association and the map. Once they negotiated the steep hill, then they could effectively pick up their original azimuth and find the point.

Table 5. Times between Points 3 and 4 from Land Navigation Practical Exercise (MM:SS)

Course	Sample Statistics		
	Mean	**Std. Dev.**	**Std. Error**
WP 1	1:52	1:13	00:05
WP 2	2:10	1:21	00:06
WP 3	1:58	1:15	00:05

Table 6 contains land navigation times as they relate to cadet performance on the post-tests for the control group, individuals who did the level 2 IMI, and the level 3 IMI cadets, for the Basic Map Reading and Determine Azimuth lessons only. These lessons were deemed to be the ones with the greatest potential impact on cadet performance at-large on the virtual land navigation course.

In order to establish a bona fide baseline in the IMI for above average and below average performers, cut-offs were established at _-standard deviation above or below the sample mean post-test scores for the MAP and DA lessons. Cadets that fell within _-standard deviation of the mean had their land navigation times omitted from the sample for this hypothesis test. Specifically, they were labeled as "average performers" in the IMI for that lesson block and, according to the hypothesis, would have no marked advantage or disadvantage in the land navigation course.

Table 6. Post-test Cut-off Scores and Land Navigation Statistics (MM:SS)

Lesson	Cut-off Score	Time	Std. Dev.	Std. Error
MAP (CG)	<= 76	9:27	4:23	00:34
	>= 85	8:15	3:35	00:25
DA (CG)	<= 77	9:02	2:39	00:24
	>= 90	8:15	3:25	00:21
MAP (IMI 2)	<= 81	8:16	2:50	00:30
	>= 89	8:44	3:45	00:32
DA (IMI 2)	<= 88	9:22	5:29	00:49
	>= 96	8:10	2:53	00:20
MAP (IMI 3)	<= 80	9:32	3:02	00:24
	>= 88	8:15	3:19	00:21
DA (IMI 3)	<= 85	9:21	2:56	00:33
	>= 95	9:11	3:24	00:23

ANALYSIS

To test the first hypothesis, H1, the pre- and post-test data for those cadets executing the MS102 lessons incorporating level 2 and level 3 interactive content were evaluated. H1 stated that the cadets who did the IMI would perform better in the post-test after completing the associated IMI lesson than they did in the corresponding pre-test. The null hypothesis, H_0, is that there is no difference in pre- and post-test scores for the IMI cadets, or $H_0^{(1)}$: $\mu_{IMI2-post} = \mu_{IMI2-pre}$ and $H_0^{(2)}$: $\mu_{IMI3-post} = \mu_{IMI3-pre}$, where the indices denote mean pre- and post-test scores for the level 2 and level 3 IMI lessons. A two-tailed t-test at a confidence level of 95% was executed. A statistically significant result is identified by $p<0.05$. Tables 7 and 8 show the results of the test and resulting t-values. All tests returned $p=0.000$. Therefore, both the levels 2 and 3 IMI courseware directly contributed to improved cadet performance on the lesson post-tests for Basic Map Reading, Operational Terms and Graphics, and Determine Azimuth.

Table 7. Data for Hypothesis H1 – Level 2 IMI

Lesson	Sample Statistics		
	Pre-test	**Post-test**	**t-value**
MAP	0.7287	0.8523	28.73
OTG	0.8210	0.8586	11.64
DA	0.8400	0.9225	17.67

Table 8. Data for Hypothesis H1 – Level 3 IMI

Lesson	Sample Statistics		
	Pre-test	**Post-test**	**t-value**
MAP	0.7216	0.8378	28.51
DA	0.8290	0.9000	12.24

For the second hypothesis, H2, post-test data for the control group in all three lessons – Basic Map Reading, Operational Terms and Graphics, and Determine Azimuth – were compared to post-test data for the level 2 and level 3 IMI lessons on the same subjects. This was done in two separate statistical tests. Here, H_0 stated that there is no difference between the post-test scores for the control group and the level 2 and level 3 IMI cadets. In other words, $H_0^{(1)}$: $\mu_{IMI2-post} = \mu_{CG-post}$ and $H_0^{(2)}$: $\mu_{IMI3-post} = \mu_{CG-post}$. Again, a two-tailed t-test at a 95% confidence level was conducted, with $p<0.05$

identifying a significant result. Tables 9 and 10 show the outcome of these tests and corresponding t-values. All tests resulted in $p=0.000$. Therefore, both the levels 2 and 3 IMI courseware contributed directly to improved mean cadet performance on the lesson post-tests for Basic Map Reading, Operational Terms and Graphics, and Determine Azimuth when compared individually to the post-test scores of the respective control groups.

Table 9. Post-test Data for Hypothesis H2 – Control Group versus Level 2 IMI

Lesson	Sample Statistics		
	Control Group	**Level 2 IMI**	**t-value**
MAP	0.8059	0.8523	10.80
OTG	0.6470	0.8586	66.03
DA	0.8336	0.9225	19.07

Again, the control group consisted of those cadets who executed only the printed course programmed text assignment for a given lesson prior to taking the same lesson post-tests as their counterparts who did the IMI lessons.

For hypothesis H3, post-test data for the lessons represented in both level 2 and level 3 fidelity – Basic Map Reading and Determine Azimuth – were compared between the levels 2 and 3 IMI.

Table 10. Post-test Data for Hypothesis H2 – Control Group versus Level 3 IMI

Lesson	Sample Statistics		
	Control Group	**Level 3 IMI**	**t-value**
MAP	0.8059	0.8378	7.84
DA	0.8336	0.9003	11.44

This was done to determine which IMI level between the two was more effective as an instructional tool for the given subject matter. This is a critical point, in that the difference in man-hours to create one hour of level 3 IMI courseware can be twice that required to produce the same one-hour block of IMI to level 2 specifications. This equates to approximately 150-300 man-hours per hour of interactive course materials for level 2 IMI and 300-600 man-hours for level 3.

For H3, the null hypothesis, H_0, assumes no difference between the mean post-test scores for the level 2 and level 3 Basic Map Reading and Determine Azimuth lessons. In other words, H_0: $\mu_{IMI2\text{-}post} = \mu_{IMI3\text{-}post}$. The two-tailed t-test with 95% confidence level and $p<0.05$ was conducted. Table 11 shows the mean scores and corresponding t-values. For Basic Map Reading, level 2 IMI was proven to produce better post-test results than the level 3 courseware with a level of significance, p, equal to 0.001 ($p<0.05$ shows a significant result). For the Determine Azimuth lesson, the level 2 courseware again produced better results than the corresponding level 3 IMI. This result was statistically significant as well, registering $p=0.000$.

Table 11. Post-test Data for Hypothesis H2 – Level 2/Level 3 IMI

Lesson	Sample Statistics		
	Level 2 IMI	**Level 3 IMI**	**t-value**
MAP	0.8523	0.8378	3.36
DA	0.9225	0.9003	4.75

The fourth hypothesis, H4, attempts to establish a relationship between the level of IMI presentation in the Basic Map Reading lesson of a given MS102 course sequence and performance on the virtual land navigation course in "America's Army." Since the Basic Map lesson contained all of the skills inherent to successful negotiation of a land navigation course, this hypothesis seems logical. The null hypotheses for H4 assumes no difference in the total elapsed times between MS102 course WP 1 and WP 2, as well as WP 1 and WP 3. As shown in Table 1, course sequence WP 1 had the level 3 IMI lesson for Basic Map Reading, WP 2 had level 2 IMI for Basic Map, and WP 3 was the control group for this lesson.

The mean land navigation times are again assumed equal in the null such that $H_0^{(1)}$: $\mu_{WP1} = \mu_{WP2}$ and $H_0^{(2)}$: $\mu_{WP1} = \mu_{WP3}$. The t-test yields the data in Table 12 (95% confidence level, $p<0.05$) with $p=0.013$ for WP 1 and WP 2 and $p=0.166$ for WP 1 and WP 3. Therefore, there is statistical significance in the markedly better mean land navigation times between courses WP 1 and WP 2, where WP 1 has the level 3 IMI for Basic Map Reading. However, there is not a significant result between WP 1 and WP 3. Despite the fact that WP 3 was the control group for Basic Map, it is possible that better times were achieved due to having level 2 IMI for Determine Azimuth, among other possible factors that were not eliminated in use of a 5% Trimmed Mean in this case.

Table 12. Completion Time Data, by IMI Course, for Land Navigation Practical Exercise (MM:SS)

Course	Sample Statistics		
	Mean	**Std. Dev.**	**t-value**
WP 1/	8:32	3:19	2.52
WP 2	9:13	3:12	
WP 1/	8:32	3:19	1.39
WP 3	8:34	3:48	

For H5, the null hypothesis assumes no difference between the mean elapsed times between points 3 and 4 on the virtual land navigation course for the three MS102 IMI course layouts. Hence, $H_0^{(1)}$: $\mu_{WP1} = \mu_{WP2}$ and $H_0^{(2)}$: $\mu_{WP1} = \mu_{WP3}$ once again. However, the means represent the times between two of the six points on the course. To reiterate, point 4 is seemingly the most difficult, whereby cadets must rely heavily on terrain association and map reading rather than simply on dead reckoning. Again, using the two-tailed t-test with 5% Trimmed Mean at a 95% confidence level and $p<0.05$ for significance, the data in Table 13 was acquired. The mean elapsed time between points 3 and 4 for WP 1 – the course with level 3 interactivity for Basic Map Reading – yields a statistically significant result over the mean times for courses WP 2 and WP 3. For the t-test of WP 1 and WP 2, $p=0.000$ and for WP 1 and WP 3, $p=0.008$. Hence, WP 1 produces better inherent understanding of the map reading and terrain association than the other two courses that have less interactivity for the Basic Map Reading lesson.

Table 13. Time Data, by IMI Course, between Points 3 and 4 of Land Navigation Practical Exercise (MM:SS)

Course	Sample Statistics		
	Mean	**Std. Dev.**	**t-value**
WP 1/	1:52	1:13	4.05
WP 2	2:10	1:21	
WP 1/	1:52	1:13	2.67
WP 3	1:58	1:15	

For the sixth and final hypothesis, H6, the null assumes no difference in the mean elapsed times between above average and below average performers in levels 2 and 3 IMI for Basic Map Reading and Determine Azimuth.

As such, $H_0^{(1)}$: $\mu_{CG-Above} = \mu_{CG-Below}$,
$H_0^{(2)}$: $\mu_{IMI2-Above} = \mu_{IMI2-Below}$, and
$H_0^{(3)}$: $\mu_{IMI3-Above} = \mu_{IMI3-Below}$, for Basic Map Reading.

Likewise, $H_0^{(4)}$: $\mu_{CG-Above} = \mu_{CG-Below}$,
$H_0^{(5)}$: $\mu_{IMI2-Above} = \mu_{IMI2-Below}$, and
$H_0^{(6)}$: $\mu_{IMI3-Above} = \mu_{IMI3-Below}$, for Determine Azimuth.

Using the two-tailed t-test once again (95% confidence level, $p<0.05$), all but two of the cases yielded a statistically significant reduction in elapsed time between the above average and below average performers on the lesson post-tests. See Table 14 for results. For Basic Map Reading, $p=0.006$ for the control group and $p=0.001$ for the level 3 IMI cadets. On the Determine Azimuth lesson, $p=0.041$ for the control group and $p=0.03$ for the level 2 DA cadets. Only the level 2 Basic Map cadets and level 3 DA cadets failed to show a significant result. This is consistent with the descriptive statistics generated for hypotheses 4 and 5, both also dealing with land navigation times coupled to IMI levels for Basic Map and Determine Azimuth across the three MS102 courses/IMI lesson combinations. Course WP 2 had the worst elapsed times, both over the entire virtual land navigation course and between points 3 and 4 in "America's Army." WP 2 had level 2 IMI for Basic Map and level 3 for Determine Azimuth, which are the subgroups that failed to show a statistically better result in the hypothesis tests supporting H6.

Table 14. Post-test Cut-off Scores and Land Navigation Times (MM:SS)

Lesson	Cut-off Score	Time	t-value
MAP (CG)	**Lower:** <= 76	9:27	2.82
	Upper: >= 85	8:15	
DA (CG)	**Lower:** <= 77	9:02	-0.56
	Upper: >= 90	8:15	
MAP (IMI 2)	**Lower:** <= 81	8:16	3.48
	Upper: >= 89	8:44	
DA (IMI 2)	**Lower:** <= 88	9:22	2.10
	Upper: >= 96	8:10	
MAP (IMI 3)	**Lower:** <= 80	9:32	2.24
	Upper: >= 88	8:15	
DA (IMI 3)	**Lower:** <= 85	9:21	0.55
	Upper: >= 95	9:11	

Additional Analysis

Numerous attempts were made to significantly reduce, if not eliminate, known or potential sources of bias in the data. These efforts manifested themselves in the interactive courseware, the land navigation practical exercise in "America's Army," and in the overall experimental design and evaluation methodology.

First and foremost was the creation of three distinct MS102 courses for map reading and land navigation, each with a unique lesson combination and varying levels of interactivity in the courseware. Each member of the USMA Class of 2006 enrolled in MS102 was aligned with only one of these unique course sequences. This took the burden off the students and instructors, the latter having to make sure that his or her sections had the correct URLs for their respective web-based lessons and, the former, to make certain that they executed correctly. In addition to gaining the purest data set possible, the three courses also ensured that each cadet and instructor got to experience the IMI for one or more lessons of the map reading and land navigation portions of MS102. The most important benefit in terms of experimental results was that it compensated in large part for the different types of "learners" present among the fourth class cadets. It is widely documented that some students are visual learners while others learn by some other stimuli or combination thereof. Others acquire skills through practical means, such as manipulation of or interaction with course materials in a problem-solving, scenario-driven environment. Still others learn best by being taught in a conventional, lecture-type forum. The course design, accompanied by various combinations of IMI, accomplished this very well as is evident in the experimental outputs.

With respect to the land navigation practical exercise in "America's Army," the use of a standardized pace count among all cadets served as a means of "normalizing," so to speak, the resulting elapsed time data. On an actual land navigation course that a soldier might be required to negotiate, one's pace count directly translates to how quickly one covers ground. All other factors being equal, this will undoubtedly result in faster land navigation times for those cadets with greater stride – a smaller pace count, or fewer steps per meter. In the "America's Army" scenario, the pace count of the "virtual cadet" was fixed at 50. Therefore, each cadet got to experience the pace count exercise, reinforcing the importance of counting of one's footfalls and establishing a sound pace count prior to commencing any land navigation exercise. The standardized pace count lended itself to ease of data analysis, as cadets were not inherently rewarded or penalized based on their pace count, as occurs in a real-world land navigation exercise.

Various other measures were taken, to include automated data collection whenever possible. As discussed earlier, although all data were collected, only first-time pre- and post-test data, as well as land navigation elapsed times, were used in the analysis. This averted the unintentional introduction of unwanted bias into the statistical samples.

SUMMARY

In USMA's distance learning pilot, a large-scale experiment was conducted to evaluate the effectiveness of IMI in a military science education framework. Six hypotheses were tested, linking several levels of interactivity of the on-line courseware with improved performance in various map-reading and land navigation evaluations. Statistically significant results were determined in the following cases: (1) cadets who executed IMI lessons performed better on web-based post-tests than they did on pre-tests of like format covering the same material and student performance objectives, (2) cadets who executed levels 2 or 3 IMI for a given lesson performed better on post-tests than their counterparts in the control group who prepared for class using only the printed course programmed text, (3) cadets who did the level 3 IMI for the Basic Map lesson had better overall elapsed times on the virtual land navigation course in "America's Army", as well as better times over the most demanding portion of the six-point virtual land navigation course, and (4) above average scorers in Basic Map and Determine Azimuth IMI lessons performed better on the virtual land navigation course than below average IMI students with two exceptions – level 2 IMI case for Basic Map and level 3 IMI for Determine Azimuth.

CONCLUSIONS & RECOMMENDATIONS

Cadets who executed the level 2 IMI courseware performed unilaterally better on the web-based post-tests than their classmates in the control group and level 3 group. On the "America's Army" land navigation course, cadets who were in the control group for either Basic Map or Determine Azimuth and in the level 2 or 3 IMI group for the other lesson performed markedly better than cadets who did IMI for both lessons. In a practical sense, this might lead one to question whether converting the MS102 course at USMA in total to IMI format is a wise course of action or not. In a much more general sense, the issue of whether or not to convert an entire course of any type solely to IMI comes into question. We contend that the degree to which student performance is enhanced through the application of IMI courseware is directly linked to two criteria. These are (1) selection of the correct task(s) to be represented in the IMI, and (2) choosing the appropriate level of presentation in terms of IMI fidelity. Therefore, unless a given course – academic or otherwise – is ideally suited for IMI across the board, committing the substantial funds required for software development may not be the best option. Therefore, in order to strike the delicate balance between fiscal prudence and maximizing student performance, courses should be converted to IMI incrementally where necessary and only to the level of fidelity that is required to achieve the desired educational objectives.

The introduction of IMI into the military science curriculum at USMA via a distance learning pilot program was a resounding success. This is not only due to the fact that this first attempt at DL highlighted the various infrastructure requirements – hardware, software, personnel, and other resources. It also showed the promise that exists in the creative application of emerging technologies in the military education of officer candidates as part of their pre-commissioning development. Interactive courseware coupled with intermediate desktop simulation employing high-resolution software with excellent graphics is exciting to cadets, as it would likely be to other individuals of the same age group outside the Academy. This study showed that, in terms of improving cadet performance in standardized, on-line tests and practical exercises that relate to map reading and land navigation, IMI is effective in achieving positive, tangible results. The desired end state is that the Army will receive the next generation of commissioned officers that are at least as proficient in land navigation as in the past, if not more so. A second order benefit is that they will have been exposed to simulation at various levels to conduct not only individual task training, but also collective training in both mounted and dismounted operations. In an era of extending training dollars and "doing more with less," simulation is being employed at increasing levels, not only in the Army but across the entire military establishment and in the American workplace at-large.

ACKNOWLEDGEMENTS

The authors would like to thank the following agencies for their invaluable support of this research: PEO-Soldier and PM-Soldier Systems, Ft. Belvoir, Virginia; Alion Science & Technology, Ft. Knox, Kentucky; The Office of Economic and Manpower Analysis (OEMA) at USMA and the "America's Army" development team at the MOVES Institute, Naval Postgraduate School, Monterey, California; Department of Military Instruction, Department of Systems Engineering, and the Department of Mathematical Sciences, USMA, West Point, New York.

REFERENCES

Busciglio, H., & Teplitzky, M. (1994). *Predicting Land Navigation Performance in the Special Forces Qualification Course*. Technical Report ARI-TR-1015, Defense Technical Information Center, Ft. Belvoir, Virginia.

Department of Military Instruction. (2002). *MS102 – Ground Maneuver Warfare I – Instructor Text*, United States Military Academy, West Point, New York.

Lickteig, C., & Burnside, B. (1986). *Land Navigation Skills Training: An Evaluation of Computer and Videodisc-Based Courseware*. Technical Report ARI-TR-729, Defense Technical Information Center, Ft. Belvoir, Virginia.

Merino, D., & Abel, K. (2003). Evaluating the Effectiveness of Computer Tutorials Versus Traditional Lecturing in Accounting Topics. *Journal of Engineering Education*, Vol. 92, No. 2, 189-194.

U.S. Army Training and Doctrine Command. (2001). *TRADOC Pamphlet 350-70-2: Multimedia Courseware Development Guide*. Fort Monroe, Virginia.