

## **VBS3 Virtual Simulation in Military Science Education at USMA**

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### **ABSTRACT**

Effective integration of Live, Virtual, and Constructive (LVC) environments in military education depends on many factors. The paper reports analysis across two semesters of the US Military Academy's experience incorporating Virtual Battlespace 3 (VBS3) simulation into classroom instruction. We (1) assess the impact of VBS3 simulations on the effectiveness of military science course instruction; (2) evaluate cadets' perceptions and attitudes regarding VBS3 simulation; and (3) explore the impacts of team dynamics and leadership characteristics on cadets' team performance. These outcomes provide insights on the successes and challenges of using VBS3 in the military science curriculum. Successes include positive perceptions of VBS3 and course relevance, increasing the accuracy of self-assessment of current and future performance, and utilizing VBS3 for course content integration with cadets' field training. Our results also show that with increased use of virtual simulation, there was initially slightly decreased performance on tests and other graded events, raising questions about a possible mismatch between course assessments and what cadets learn from simulation. However, improvements in cadets' performance were identified once the instructors had more experience utilizing simulations in the classroom. Impact of virtual simulation may be improved by additional or modified assessments of the tactical skills learned using VBS3 to reinforce these skills. Increased tactical skill reinforcement may increase cadets' declarative and procedural knowledge, potentially increasing knowledge transfer into live training performance. The paper also discusses lessons learned about the simulation tool lifecycle and educational context of virtual simulation in the classroom. Successful adoption required investments in scenario development, instructor training, and simulation laboratory infrastructure. Individual faculty were able to tailor use of the virtual experience through different approaches to the platoon leader briefing, simulated pre-mission reconnaissance, real-time adjustments to the scenario and computer-controlled OPFOR, and after action review. Finally, the paper presents initial qualitative analysis of classroom observations and VBS3 game logs showing how differences in team leadership and communication impact team performance within virtual tactical scenarios.

### **ABOUT THE AUTHORS**

**Alice Leung, Ph.D.** is a Senior Scientist at BBN Technologies. Her main research interest is the application of game-based technologies for shaping and measuring human behavior. She is currently the integrated experimentation lead for the ARL Network Science CTA, exploring how to improve experimental capabilities for understanding social/cognitive, information, and communications networks. Previously she was the principal investigator for IARPA projects on serious games for mitigating cognitive biases and immersive interactive narratives for cross-cultural understanding. Prior work also includes the JFCOM/DARPA Helical Training project to apply concepts from Alternate Reality Games to military training needs and the DMSO/AFRL SABRE project to develop a game-based testbed for cultural behavior modeling and team performance research.

**Yulia Tyshchuk, Ph.D.** graduated from Rensselaer Polytechnic Institute with B.S. in Industrial and Systems Engineering and B.S. in Management. She worked as a project manager for a major financial institution on a number of cost saving initiatives. She returned to Rensselaer Polytechnic Institute in 2010 and in 2015 completed her PhD in Decision Sciences and Engineering Systems. During her PhD studies she was a member of the SCNARC (Socio Cognitive Network Analysis Research Center) research team and assisted in completion of successful grant proposals for National Science Foundation, Department of Homeland Security, and Army Research Laboratory. Her research interests include understanding, modeling, and being able to predict human behavior as expressed on

electronic media as well as incorporating network models in the studies of team composition and performance. Her current research at USMA includes the study of the effects of Virtual Battlefield Simulations on cadets' learning, team performance, and emergence of leadership. Yulia is also working on the project with Cyber Research Center that seeks to develop theory and models that will guide successful composition and enhanced performance of ARCYBER teams.

**Captain Caleb Goble** entered military service in 2000 as an enlisted infantryman. He deployed twice in support of Operation Enduring Freedom (OEF) and once in support of Operation Iraqi Freedom (OIF) as an enlistee before entering the United States Military Academy (USMA) at West Point. He graduated from USMA with a bachelor's of science degree in Arabic and received his commission as an infantry officer in 2007. He then continued his Army career in infantry, deploying in support of OEF and OIF. Captain Goble's most recent assignment was as the Brigade Planner for 1st SBCT, 25th ID from September 2014 to March 2015. He currently serves as the Course Director of Military Science 300 at the United States Military Academy.

**Lisa M. Scott** is a computer scientist with the Computational and Information Sciences Directorate at the U.S. Army Research Laboratory (Adelphi, MD). Her main interest is software development and experimental design. She was a software developer under ARL's Network Science Collaborative Technology Alliance (NS CTA) component based routing task, working to implement a software framework to interchange routing components based on the communication environment to produce dynamically robust routing protocols. Currently she is working on the NS CTA quality of information and experimentation thrusts.

**Ly Dinh** is a second-year Master's student and research fellow at the Department of Communication, University of Illinois Urbana-Champaign. Her research interests lie at the intersection of computational social science, information diffusion in networks, and organizational communication. Her current research agenda adopts a balance-theoretic approach to studying multi-team systems trust, using data obtained from Virtual Battle Space (VBS) experimentation as part of ARL Network Science CTA program. She is particularly interested using computational models and network analysis in order to examine social and communicative dynamics in small groups and organizations. She will be joining the School of Information at the University of Illinois in Fall 2016.

**Marshall Scott Poole, Ph.D.** is the David L. Swanson Professor of Communication at the University of Illinois at Urbana-Champaign. His main interests include group and organizational communication, information systems, collaboration technologies, organizational innovation, and theory construction. He is the author of over 150 articles, book chapters, and proceedings publications and has authored or co-edited 11 books. He has also worked on the Virtual Worlds Exploratorium Project, a collaborative multi-university research project that analyzed server side and survey data from a variety of massive multiplayer online games.

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**Noshir Contractor, Ph.D.** is the Jane S. & William J. White Professor of Behavioral Sciences at Northwestern University, USA. He is investigating factors that lead to the formation, maintenance, and dissolution of dynamically linked social and knowledge networks. His research program has been funded continuously for two decades by major grants from the National Science Foundation, as well as other agencies including the Army Research Laboratory, and the Gates Foundation. He received the National Communication Association 2014 Distinguished Scholar Award recognizing a lifetime of scholarly achievement in the study of human communication and was elected a Fellow of the International Communication Association in 2015.

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### **INTRODUCTION**

Virtual Battlespace (VBS) is the U.S. Army's game-based military simulation platform, used for virtual tactical training and mission rehearsal. The current version, VBS3, is similar to other multi-player client/server first-person shooter games, but also includes digital assets (avatars, vehicles, maps, weapons) and features (after action review recording, a library of missions and scenarios) to better support military use in teaching doctrine, tactics, techniques, and procedures for squad and platoon offensive, defensive, and patrolling operations. User-authoring of scenarios enables military trainers to develop custom missions for their specific needs. Military creativity, combined with VBS flexibility, has led to a wide variety of training, rehearsal, assessment, and research uses.

The Marine Corps Infantry Officers Course, in coordination with the Marine Aviation Weapons and Tactics Squadron (MAWTS-1), is using VBS3 to train new infantry officers while the USMC Live Virtual Constructive Regional Capabilities START Assessment (LVC RCS) is studying the effectiveness of VBS3 training for infantry, close air support, and CASEVAC or MEDEVAC missions. The Joint Army, Navy, and Marine Corps Squad Overmatch and Tactical Combat Casualty Care (SoVM/TC3) Training Effectiveness Evaluation is studying VBS3 as part of a virtual to live training curriculum (Brimstin et al., 2015; Milham et al., 2016; Ogden et al., 2015). Non-training applications have included assessing traits of successful scenario developers (Lackey, Maraj, and Salcedo, 2015), measuring tactical level situation awareness (Bew et al., 2015), and assessing readiness to Return-to-Duty (Parsons and Reinebold, 2011). The USMC Deployable Virtual Training Environment (DVTE) for small unit tactical decision-making uses VBS3, as shown by the Operation Blended Warrior team at IITSEC 2015.

An important part of education at US Military Academy (USMA) is the Military Science Program, which focuses on the knowledge and skills needed for sound tactical decision-making under pressure. The final course in this program is Military Science 300: Platoon Operations (MS300). Cadets generally complete MS300 during their third year, prior to the summer Cadet Leadership Development Training (CLDT) field exercise. In 2015-2016, instructors at the USMA adopted in-class VBS3 virtual simulation for use in the MS300 course, with pilot-scale deployment in Spring 2015 and full-scale deployment in Fall 2015/Spring 2016. In contrast to more specialized VBS3 use as part of on-the-job military training in the services, USMA adoption of VBS3 was designed to illustrate and reinforce basic infantry tactics and Troop Leading Procedures.

### **VBS3 VIRTUAL SIMULATION AT USMA**

During the 2014/2015 academic year, the MS300 Platoon Operations course curriculum was revised to more closely align with the Cadet Leadership Development Training (CLDT) summer field exercise. The goal of both MS300 and CLDT is to prepare cadets for future roles as Army Officers; the learning objectives include demonstrating understanding of:

- Army operational doctrine and small unit tactics and how to apply them to mission planning.
- The troop leading procedures to plan a tactical operation as a platoon leader.
- The principals of direct fire planning to effectively employ organic and attached weapon systems.

- Effectively planning to leverage battlefield assets at the platoon level to accomplish assigned tactical missions.
- The Law of War, Rules of Engagement and the Code of Conduct and how to apply them to a tactical scenario.

The learning objectives also include demonstrating the ability to:

- Analyze and extract pertinent information from higher headquarters orders, and apply this information to tactical problems to develop workable courses of action.
- Clearly communicate a tactical course of action both verbally and visually, using the appropriate graphics and symbols.

The purpose of adopting VBS3 virtual simulation as part of MS300 was to provide an experiential learning opportunity for cadets to see the consequences of applying military science principles for tactical planning, communication, and decision-making. By engaging in the scenarios, cadets could have virtual experiences demonstrating why certain practices, such as establishing sectors of fire, are so important and could practice applying tactical principles, such as deploying obstacles in conjunction with terrain. Figure 1 shows a scene from one of the custom VBS3 scenarios USMA created to illustrate basic tactical concepts at a platoon level.

Each semester, 400-600 cadets are divided into separate sections of about 18 students; these sections are taught by a group of faculty from the Department of Military Instruction. The course syllabus and graded activities are centralized, but each instructor tailors lectures and activities for their section according to their own expertise and interests. During the Spring 2015 pilot-scale deployment of VBS3, three modules covering short (10-15 minute) platoon-level scenarios involving an ambush, raid, and defense were developed. Some instructors chose to use all three scenarios, while others used only the defense scenarios. No additional classroom times was allocated, so any use of VBS3 simulation substituted for other classroom instruction. During the full-scale VBS3 deployment in 2015/2016 academic year, all sections of MS300 for both fall and spring semesters used the simulation lab to engage with all three scenarios. Additionally, select instructors chose to use more than one class hour per scenario and conduct test runs prior to scheduled simulation events.



**Figure 1. USMA created platoon ambush, raid, and defense platoon scenarios in VBS3.**

Our research team collected observation notes, conducted survey questionnaires with cadets and instructors, and interviewed instructors. In collaboration with USMA instructors, we also analyzed de-identified grade and rating data from MS300 and CLDT. We observed:

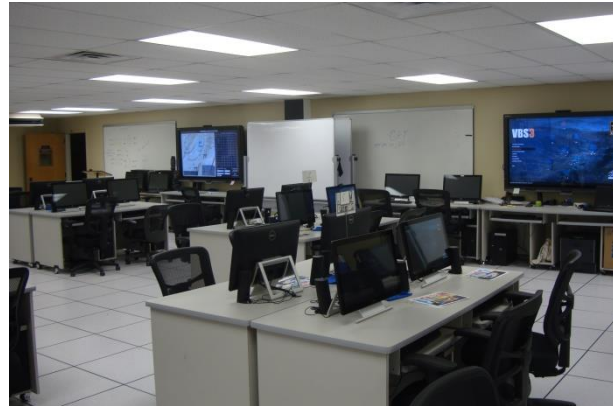
- Multiple sections of MS300 during sessions using the defense scenario during Spring 2015.
- Train-the-trainer sessions during Summer 2015, where the MS300 instructors played through the raid scenario and learned to operate VBS3.
- Parts of the CLDT field exercise during Summer 2014 and Summer 2015.
- Multiple sections of MS300 during sessions using all three scenarios during Fall 2015 and Spring 2016.

During Fall 2015, we also recorded video in the simulation lab of the platoon leader briefs and the cadets during scenario sessions. We collected survey questionnaires from MS300 cadets during Spring 2015 and Spring 2016 about their experiences and perceptions related to VBS3 and tactical skills. We analyzed grade and rating data from MS300 Spring 2015, CLDT Summer 2015, and MS300 Fall 2015 and Spring 2016 semesters.

Adoption of a new technology, particularly in an already full curriculum, is a challenge requiring a range of technological, pedagogical, and logistical support. USMA's successful VBS3 deployment relied on several

technology pioneers and advocates, who initially explored and evaluated the VBS3 software, and later trained instructors to operate the simulation. The academy's simulation lab and staff handled software installation, hardware and network compatibility issues, and software configuration in addition to providing technical assistance during the VBS3 simulation sessions. Some challenges included mismatched between institutional IT policies discouraging the use of shared computer accounts and the infeasibility of creating and configuring individual cadet accounts for VBS3 simulation sessions. Figure 2 shows the USMA simulation lab, where VBS3 exercises are conducted.

The technology pioneers also had deep expertise in the MS300 curriculum, making it possible for them to develop the sequence of three short VBS3 modules focused on key concepts from the syllabus. Each scenario was designed to accommodate up to 20 participants (a complete course section) representing a platoon with three Rifle Squads and a Weapons Squad. The unit echelon level and scenario topics mirror those used in the CLDT exercise. The scenario missions were designed to play out over 10-15 minutes, so that 2-3 run-throughs of the same scenario could be completed within a single 55-minute class period. The VBS3 virtual simulation learning experience included a significant amount out-of-game pedagogical content framing the gameplay. Cadets were given the mission background materials (e.g. maps, Road to War, operation orders) and asked to prepare plans and an Operations Overlay (briefing diagram) ahead of time. Individuals were selected to fill the role of platoon leader, verbally briefing their classmates/platoon members on the mission plan. Instructors included a simulated leaders' recon session before the mission, and conducted an after action review (AAR) after each scenario play-through. During the play-through, many instructors coached the platoon leader and other cadets when they ran into difficulties with tactical procedures such as calling for indirect fire. Instructors customized their approaches to the pedagogical content framing the simulation, and also their use of the simulation. For example, one instructor emphasized the importance of correct and clear Operations Overlays by assigning cadets to deliver another person's prepared plan, based only on seeing this diagram. Some instructors used the VBS3 real-time scenario editor to tailor the challenge level, adding more enemy reinforcements or resurrecting platoon casualties.



**Figure 2. The dedicated simulation lab can be used by two course sections at the same time.**

## IMPACT OF VIRTUAL SIMULATION

We analyzed the impact of virtual simulation on USMA cadets in several ways:

- Statistical comparison between MS300 sections during Spring 2015, comparing sections who experienced high versus low VBS3 use. We compared their answers on survey questions about perceptions, their grades in MS300, and instructor ratings on the Summer 2015 CLDT exercise.
- Statistical comparisons between Spring 2015, Fall 2015, and Spring 2016 semesters, looking at cadet grades on various MS300 tests and graded events.
- Qualitative observations of virtual simulation sessions across multiple semesters and instructors.
- Interviews with instructors.

The next sections address analysis of the pilot-scale deployment first, followed by analysis of the full-scale deployment.

### Pilot-Scale Deployment Results: Perceptions and Self-Assessment

At the end of the MS300 course during the Spring of 2015, 75 cadets from the course were surveyed about game-based simulation and small unit tactical learning objectives. The study purpose was to understand how the use of game-based simulation during MS300 may help prepare cadets for the CLDT field training (see Figure 3 for an illustration of CLDT) by contributing to their understanding of tactics and planning. The cadets were divided into two groups, with the high treatment group being selected from course sections that had used VBS3 simulation more

often and the low treatment group being selected from course sections that had used VBS3 simulation less often during MS300. A possible confounding factor was that the course sections were taught by different instructors. Each instructor was working from the same course content outline, but there could be additional differences beyond amount of VBS3 use between the sections.

The survey questions asked cadets to provide information about a range of topics, including:

- Prior first person shooter game experience/expertise.
- Amount of use of VBS3 in MS300.
- Opinion of how useful MS300 was, with respect to various learning objectives.
- Opinion of how useful VBS3 was, with respect to the same learning objectives.
- Self-perception of the cadet's MS300 performance.
- Self-estimate of the cadet's CLDT future performance.



**Figure 3. Both the MS300 course and summer CLDT field exercise focus on the skills and knowledge a Platoon Leader needs.**

### **Performance**

In the pilot study, the overall average MS300 and CLDT grades were similar between the low and high VBS3 use groups (low group: 831/1000 in CLDT, 87/100 in MS300; high group: 835/1000 in CLDT, 90/100 in MS300). The slightly higher MS300 average grade in the high treatment group is statistically significant, while the slightly higher CLDT grade is not.

In the low treatment group, there was a moderate negative correlation between MS300 performance and CLDT performance. In contrast, for the high treatment group, there was a moderate positive correlation between MS300 and CLDT performance. Thus, cadet MS300 performance grade in the high treatment group was more predictive of CLDT performance. This might suggest that MS300 content and assessments in the high treatment group were more closely tied to CLDT, or that the cadets in the high treatment group were better able to transfer skills and knowledge learned in MS300 to CLDT.

In the high treatment group only, there was a strong correlation between prior game experience and MS300 performance, and a moderate correlation between prior game experience and CLDT performance. This suggests that when VBS3 is used more in MS300, those cadets with more prior game play experience see greater MS300 performance and CLDT performance. Instructors may want to consider ways to help those cadets with minimal prior game playing experience quickly become familiar enough with VBS3 that they can benefit from the virtual simulation.

### **Perceptions**

The high treatment group reported that both MS300 and VBS3 had been more useful for mastering learning objectives, compared to the low treatment group. The low treatment group rated MS300 an average of 3.42, and VBS3 an average of 3.45 (3 = somewhat helpful, 4 = a little helpful). The high treatment group rated MS300 an average of 2.51 and VBS3 an average of 2.63 (2 = pretty helpful). This suggests that using VBS3 for an additional few days during MS300 resulted in cadets feeling that both the MS300 class and the game-based simulation were more helpful in mastering the class learning objectives.

For both groups, there was a strong correlation between how helpful they thought MS300 and VBS3 were for mastering each learning objective. This result suggests that the VBS3 experience, even for the group that did not use VBS3 very much, had a significant impact on the cadets' overall impression of what they learned in MS300.

### **Self-Assessment**

In the low treatment group, there was only weak correlation between the cadets' self-rated mastery on a single course learning objective and overall MS300 performance. In the high treatment group, there was strong correlation

between MS300 performance and cadet self-rated mastery of two objectives (applying small unit tactics and planning a tactical operation as platoon leader); moderate correlation between MS300 performance and self-rated mastery of a third objective; and weak correlation between MS300 performance and self-rated mastery of two more learning objectives. This suggests that greater use of VBS3 increased cadet accuracy in self-rating their own mastery of various learning objectives in MS300.

In the low treatment group, there was weak correlation between cadet self-estimate of CLDT performance on 4 out of 5 learning objectives and their actual overall CLDT performance, and moderate correlation on the other learning objective. In the high treatment group, there was strong correlation between cadet self-estimate of CLDT performance on 4 out of 5 learning objectives and their actual overall CLDT performance, and moderate correlation on the other learning objective. This suggests that great use of VBS3 increased cadet accuracy in estimating their future performance in CLDT.

### **Full-Scale Deployment Results: Tests and Graded Exercises**

USMA moved forward with full-scale deployment of VBS3 simulation in the MS300 course during the Fall of 2015 and Spring 2016, based on their experience with the pilot-scale deployment. During the earlier pilot-scale deployment, instructors varied in how much they used the simulation, and there was no centralized/overall integration of VBS3 material into the MS300 curriculum. During the full-scale deployment, all instructors used three VBS3 scenarios as integrated components of the MS300 course. We compared all cadets' MS300 performance between the pilot-scale deployment and the first semester of the full-scale deployment to try to understand the impact of increased VBS3 use. This comparison showed a dip in the following graded events: (1) two out of the three written tests, (2) oral desk side brief, (3) instructor points, and (4) final average grades ( $p$ -value  $< 0.05$ ). There are some issues with using this comparison to quantify the impact of VBS3 use, because a number of other factors also changed between these semesters. For example, USMA also introduced greater use of electronic textbooks and course materials. Additionally, most of the MS300 instructors change each academic year, so instructors are more experienced teaching the course in the Spring semester.

Informal interviews with instructors during Fall 2015 suggested that it may take time for the instructors to get adjusted to using VBS3 technology in the course. These adjustments include (1) learning the functionalities of the system, (2) preparing lesson plans to integrate the VBS3 instruction into the course, and (3) conducting meaningful after action review with cadets during VBS3 simulation to capture all of the learning objectives. After Fall 2015, the instructors adjustments by allocating additional time to the learning objectives cadets struggled with in Fall 2015, and incorporating supporting concepts into VBS3 simulations. In order to evaluate if such adjustments took effect with a significant impact on cadets' performance, we compared performance metrics for all MS300 graded events between the Fall 2015 and Spring 2016 semesters for all sections with instructors who taught during both semesters. The collected data for the grades is non-parametric and the Mann - Whitney U test was utilized to test if there were any differences between the two semesters' grades for these selected sections. We found no statistically significant differences for the MS300 average grades, however, the cadets' scores for two out of three written tests (i.e. two written tests worth 10% and 7.5% respectively) significantly improved ( $p < 0.05$ ). There was a notable decrease in the points subjectively assigned by instructors (i.e. instructor points) and by the fellow cadets (i.e. peer evaluations). Additionally, there was a decrease in the warning order graded assignment (i.e. short assignment worth 2.5% of the grade) and one of the written tests (i.e. written test worth 7.5% of the grade). Overall, the returning instructors achieved significant improvements in cadet performance on some graded events. Further improvement may be possible by focusing on capturing the learning objectives evaluated on the written test that had a decrease in performance and by further emphasizing the learning objectives of other assignments in the VBS3 simulation.

### **CHALLENGES IN EDUCATIONAL USE OF VIRTUAL SIMULATION**

Study of the pilot-scale and full-scale incorporation of VBS3 into the USMA MS300 course illustrates a number of key challenges for the general case of deploying game-based activities in an educational setting:

- Integrating the simulation into coordinated learning, reinforcement, assessment programs.
- Management of multi-year initiatives across annual staff rotation.
- Developing a culture of taking game-based learning seriously.
- The technology learning curve.
- Uneven prior experience and attitudes toward gaming.

- Inefficiency when many students play roles other than the one that most closely matching their learning interest.
- The temptation of social loafing in large groups.

In the rest of this section, we discuss ideas for addressing these concerns.

### **Institutional Culture and Practices**

Our comparison of cadet grades before and after full deployment of VBS3 simulation in the MS300 course did not find any clear overall improvement. It is possible that learning improvement is difficult to examine simply through average course grades. Potentially, the simulation itself could be used as a means of performance assessment (Gee and Schaffer, 2010), analyzing how much cadets improved at meeting mission objectives between runs. More study is needed to understand whether the incorporation of virtual simulation improved cadet learning in the course or not, and what changes might be needed to more fully realize the educational potential of this technology for interactive, immersive learning. It is not clear where virtual simulation will have the strongest impact within the educational process of first learning knowledge or skills, then applying them to different situations, and finally reinforcing and assessing mastery. In the future, instructors may explore variations on when and how the simulation is used to introduce, reinforce, or assess cadets.

In achieving the transition from pilot-scale to full-scale deployment, USMA faced the challenge of planning and implementing a multi-year initiative in a department where many instructors serve a one-year rotation. To improve upon the initial technology deployment, they must continue to work toward the initial vision and retain institutional knowledge of technological and practical details. The Department of Military Instruction relies on both multi-year active military staff and longer term civilian (retired military) staff to provide such continuity.

### **Game Technology**

Despite the perception that all young people play computer games, in our Spring 2015 survey, we found that a minority of cadets (15%) in our MS300 study sections had no experience playing first-person shooter games, and another 18% played such games only monthly during their prior most active period of game playing. These numbers suggest that over 30% of cadets may be unfamiliar with the keyboard shortcuts, commands, and UI conventions of a first person shooter game. USMA instructors found it necessary to teach the basics of how to move, shoot, and take other actions in the game before VBS3 simulation could be used to illustrate platoon tactics. During the simulation sessions, many cadets relied on asking their classmates, asking the instructor, or reviewing game control summary sheets. Through a combination of an initial short hands-on training and just-in-time question answering, instructors were able to get nearly all the cadets past the game interface learning curve during the first simulation session. Potentially, instructors could offer individuals with little experience playing first-person shooter games the opportunity to play through an automated game tutorial prior to the first simulation session.

The instructors faced their own learning curve in mastering the game administrator controls for starting, resetting, on-the-fly adjustments, and conducting after action review of the scenarios. USMA supported a number of the instructors by pairing them with a simulation operator, allowing the instructor to focus on observing and interacting with the cadets. This technique was a successful way to enable instructor to more confidently use the VBS3 simulation during the first full deployment semester.

Instructors at USMA were aware of the danger that cadets might not take game-based learning seriously, considering the simulation just a fun or frivolous activity, and “playing around” with it. The instructors minimized this danger in several ways. First, during the initial game-control training, some instructors explicitly encouraged the cadets to engage in the most obvious unrealistic activities (such as shooting wildly at anything that moves) that new players might be tempted to explore. Additionally, the instructors began the simulation sessions by having cadets prepare and deliver mission briefs, standing in front of the class, establishing a serious tone, and initiating immersion in the tactical scenario. Many instructors maintained this serious tone by ending the scenario after the important consequences played out but before the action slowed too much, minimizing the opportunity for any virtual “horsing around.” Cadets took cues from their instructor about the importance of the MS300 course material and potential utility of VBS3 simulation. We found that the MS300 sections with the most positive and least positive average cadet impressions of VBS3 during Spring 2016 corresponded to the sections taught by the instructors who

themselves had the most and least positive impressions during the previous semester. This suggests that instructors may transfer their attitudes and perceptions to their students.

### **Group Scenarios**

Both MS300 and CLDT focus on skills and knowledge for Platoon Leaders, because that is a common first assignment after graduation. Yet, in order to provide a simulated platoon for the cadet playing the leader role to engage in believable platoon coordination and communications activities, a number of other cadets must play the role of enlisted members. This mirrors a challenge common to other simulation-based training activities; when person-to-person communication and coordination are key parts of the task, computer-controlled characters are rarely able to provide sufficiently believable behaviors, so either other students or trainers must devote time to playing the supporting roles.

During CLDT field exercises and MS300 VBS3 exercises, instructors deliberately prompt the cadets to rotate through the roles of Platoon Leader and Squad Leader, giving each cadet an opportunity to receive individualized coaching. Still, cadets spend the majority of their time playing supporting roles, potentially decreasing the efficiency of learning time. For computer-mediated exercises, there is the potential for incorporating computer-controlled entities to fill some of the supporting roles, potentially providing more opportunities for each cadet to practice in leadership roles. Recent work integrating machine learning, cognitive systems, and artificial intelligence with game engines (e.g. Soar Technology and Unreal Engine 4) may enable such capabilities. USMA already uses computer-controlled entities in VBS3 to play the opposing forces. In the future, they may consider the feasibility of running multiple VBS3 simulations at once, dividing the section into multiple separate simulations, each with five cadets playing leadership roles with computer-controlled platoon members. This would increase the complexity of running the simulation session, as well as significantly increasing the demand on the instructor to observe and mentor multiple groups at once.

Another concern that may be addressed by dividing the section into multiple simultaneously simulated units is the danger of non-engagement (e.g. “social loafing”). In a large group, it can be tempting for some individuals to participate minimally, relying on other more active members to achieve the group goals through their efforts. A smaller group size can increase each individual’s visibility and accountability to the group, spurring greater engagement and potentially more learning.

### **CADET VBS3 TEAM PERFORMANCE**

We observed approximately 30 simulation sessions during the first two semesters of full-scale VBS3 deployment, taught by 6 different instructors. In this section, we describe some qualitative differences between instructor styles and some differences in the cadets’ simulated platoon performance. We highlight some of the observed instructional practices that future instructors may find useful. During each simulation session, approximately 16 cadets played leaders and members of a platoon divided into four squads. Each session focused on an ambush, raid, or defense scenario, with cadets completing two run-through of the scenario. This enabled cadets to apply what they learned from the first run-through during the second.

#### **Instructor Styles**

Each instructor draws on their own experience and expertise when presenting the material. They use a variety of approaches to build rapport with the cadets and communicate the importance of different topics. Though the learning objectives for the course are standardized across sections, the format allows each instructor to tailor the use of the simulation to best fit their priorities. Some differences between instructors included:

- Task simplification and scaffolding. Some instructors allowed the platoon leader to walk around the room, making it easier to maintain overall situation awareness, or encouraged use of a simplified process to call for fire. Others “resurrected” some platoon members who were early casualties, or intervened in the computer-controlled red force, to increase challenge level.
- Coaching and feedback on mission plan, prior to first play-through. Some instructors highlighted missing aspects of the plan, or asked the rest of the class for additional suggestions to improve the plan.
- Coaching or prompting during the scenario. Some instructors asked the platoon leader for status updates, cueing them to check in with squad leaders.

The instructor teaching styles can be divided into three categories. Two instructors employed a relatively *laissez-faire* teaching style in which cadets, especially the platoon leader, had high autonomy and minimal instructor guidance in decision-making and mission control. Two instructors used a more *directive* teaching style, exerting direct influence to guide cadets to base their strategies on standard military tactical doctrine. Two instructors employed a *participative* style, in which they encouraged cadets to use military doctrine, but also allowed cadets to improvise in the first of the two play-throughs, which sometimes led to major errors. Based on learning from the first iteration, these instructors then coached cadets in military doctrine as they prepared for the second mission.

Platoon performance during each session was differentiated into three levels—low, moderate, and high—based on problems that emerged during the mission and instructor comments on effectiveness during the after-action review of the session. We were only able to make confident assessments of effectiveness for 17 of the sessions.

In comparing the impact of each instructor's teaching style on mission outcomes, we did not find any notable correlation. Each of the instructors had sessions at all three levels of performance. We did, however, notice that the five sessions that were most effective were supervised by participative instructors who gave opportunities for initiative/exploration, and also provided guidance in terms of both navigating the VBS3 environment and how to effectively use military doctrines.

We also noted two potential techniques that instructors used to increase engagement in mission planning/analysis among cadets not playing platoon or squad leader role. First, if there is a simulation operator separate from the instructor, the simulation operator can handle the leader recon activity prior to the play-through, freeing up the instructor to lead the rest of the class in an analysis of the mission plan. Second, as some cadet avatars are casualties in the simulation, they might be encouraged to join the simulation operator behind the screen to watch the rest of the play-through unfold from a broader point of view.

### **Communications Patterns in the Platoon**

We used Notability, interactive note-taking software, to capture and visualize real-time communication patterns among cadets during the simulation sessions. Data were collected on tablet computers with the layout of the cadet stations as a template for recording. Recorders used the tablet stylus to mark lines connecting two cadets who communicated. Broadcast messages were recorded using special notation, as was the communication of the platoon leader. The resulting data provided a map of communication networks during the session. The tablets also recorded sequence of stylus strokes, so the evolution of the communication network could also be viewed as a “movie.” For purposes of this analysis, only the final communication network diagrams were used. In addition to mapping connections, observers also made general notes on the content of communication during the sessions, particularly whether the communication concerned the task or how to use VBS3. In some sessions joking and off-topic communication occurred and this was noted as well.

Communication networks were derived for 29 sessions, led by 6 different instructors. We employed inductive coding procedures similar to those used in grounded theory research to identify features of the communication network diagrams. Specifically we found that networks varied in terms of: (1) the extent to which the platoon leader initiated communication links, (2) the amount of communication within squads; (3) the frequency of inter-squad communication; and (4) the amount of broadcast (one-to-many) communication in the platoon. We then computed the proportion of total links in the network diagram which each type of communication represented and conducted a cluster analysis (hierarchical clustering, Wards method) of sessions in terms of how similar their profiles of communication were across the four types. This yielded two clusters of sessions, suggesting there were two basic network patterns.

The first type (squad-focused) consisted of sessions in which there was a high proportion of within squad communication (.70 on average), and much lower proportions of platoon leader communication (.14), inter-squad communication (.05), and broadcast communication (.14). The second type (platoon-focused) consisted of sessions in which there were higher proportions of platoon leader, inter-squad and broadcast communication with relatively lower proportion of within squad communication. Within squad communication within these sessions was still high, consisting of 32% of communication acts, about equal to the proportion of broadcast communications (.29); platoon leader communications made up 22% of acts and inter-squad communication 16% in platoon-focused sessions.

In terms of the relationship of communication network attributes to effectiveness, squad-focused sessions were rated as more effective than the platoon-focused sessions (2.4/3 on average versus 2.0/3), but the difference was not statistically significant. This is consistent with our qualitative observations which suggest that active communication across squads through broadcast and inter-squad messages is not always effective. Often individuals communicate frequently to ask for help in navigating VBS3, and this may delay effective completion of objectives. The most effective squads tend to have less dense communication link networks, and to exhibit a hierarchical communication structure in which the platoon leader communicates the strategy clearly to squad leaders, who in turn give orders to squad members who communicate primarily within the squad. It is also interesting also to find that the five most effective teams contain a high number of broadcast (one-to-many) communications. These broadcast messages help to maintain situational awareness about enemy or squad movements (e.g., "enemies coming from the northeast" or "first squad, coming in").

We also observed that there is a negative relationship between within squad communication and between squad communications. Working in the VBS3 environment is quite demanding in terms of cognitive and task load and this reduces the resources cadets have to devote to communicating. Many cadets (though by no means all) can either communicate within their squad or turn out and communicate to other squads and/or the platoon leader. As the configuration of the platoon is clearly divided in which each squad has a separate set of goals, along with a common goal to succeed in the mission, some squads focus on their own goals (i.e., the weapon squad focuses on navigating the larger weapons that can shoot from further distance) and perhaps do not have sufficient time and cognitive capacity to coordinate with other teams.

## **CONCLUSIONS**

Incorporation of virtual simulation into an already packed educational curriculum can be successful with an organized and appropriately resourced deployment plan, but there are challenges. VBS3 and virtual simulation in general may emphasize a set of skills which are not the central focus of existing assessments. For example, simulation and other interactive exercises are particularly suited to teach the application of principles across contexts and motivate learning. Including a more hands-on activity such as VBS3 simulation in military education can be a way to illustrate consequences and reinforce concepts. It can also increase learner perception of relevance, engagement, and ability to self-assess skills. The challenges in educational use of virtual simulation include integration into existing institutional practices, addressing the technology learning curve for both instructors and students, and providing efficient time-on-task learning for all simulation participants.

The USMA deployment of VBS3 simulation in MS300 provides a unique opportunity to study technology adoption and impact in an educational setting. Future analysis will examine the impact of VBS3 on cadet preparedness for field exercises, analyzing correlations between Spring 2016 MS300 performance and attitudes, and summer 2016 CLDT ratings. We will also examine VBS3 AAR recordings and classroom videos to further understand cadet learning by comparing initial and subsequent scenario run-throughs, and to explore use of different communication and coordination patterns.

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