Blending Adaptive Learning into Military Formal School Courses

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ABSTRACT

Across 87 formal learning centers, the United States Marine Corps Training Command is challenged with training large numbers of Marines with limited instructors and time available. Instructors need strategies and tools to support and enhance the student learning experience while optimizing their use of time and resources. Furthermore, due to a need to prepare Marines for tomorrow's increasingly uncertain, complex, and decentralized operating environment, MajGen Mullen, Commanding General of Training and Education Command, has called for an institution-wide shift from passive, instructor-focused training towards an active, student-centered learning model. Courses need to be designed and delivered in a way that is engaging, interactive, personalized, and that increases efficiencies for instructor time. The Adaptive Blended Learning Experience (ABLE) project addresses these challenges and extends the research and development for the areas of adaptive learning and blended learning designs.

The purpose of the ABLE effort is to develop a model to deliver Military Occupational Specialty (MOS) training content in a self-paced, adaptive format that enhances student learning and creates efficiencies for instructor time. The Tactical Intelligence Officer Course (TIOC), a Marine Corps Intelligence School course teaching Center of Gravity (COG) analysis was selected as the testbed for this preliminary evaluation. An adaptive lesson was created in Moodle (a Learning Management System) to enable self-paced learning and personalized remediation of COG analysis basic concepts so subsequent instructor-led classroom time is devoted optimally for advanced practical application exercises. An experimental study design is being applied to measure learning effectiveness and time efficiency associated with the ABLE intervention of the COG analysis module. Findings from this preliminary evaluation will inform the design of further experimental testing in comparison to current teaching practice. The results of this effort will contribute to developing a framework for effective, adaptive, blended learning course designs throughout Training Command that will be generalizable to other training and educational settings.

Keywords: adaptive learning, adaptive training, blended learning, training, Marine Corps, Moodle

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INTRODUCTION

Tasked with a mission to successfully prepare Marines to succeed in their Military Occupational Specialties (MOS), the Marine Corps Training Command faces increasing challenges, including limited number of instructors, instructor time in billet, and classroom time available. Additionally, formal school instructors face a greater need to prepare Marines as critical thinkers and self-directed, life-long learners (e.g., Weimer, 2013) who can make decisions in increasingly uncertain, complex, and decentralized operating environments. With this in mind, MajGen Mullen, Commanding General of Training and Education Command called for an institutional shift in how Marines are developed. No longer will instructor-centric, sage-on-stage instruction, where learners are passive receivers, be sufficient (Mullen, 2018). An active, student-centered learning approach is taking shape in the Marine Corps where students are challenged with problems they tackle as groups to learn by doing and from each other (United States Marine Corps, 2020). Making this shift requires efficiencies in how students learn the foundations of their MOS in order to optimize time spent in the classroom for practical application exercises.

In response to these needs, the Adaptive Blended Learning Experience (ABLE) study emerged to examine the integration of an adaptive learning tool into Marine Corps formal school courses. This paper describes the development and administration of an initial version of ABLE and preliminary findings of learning effectiveness and efficiencies associated with blending adaptive learning into a course. Additionally, the paper discusses the types of knowledge best addressed in adaptive learning. The next step in the study will be to empirically compare the outcomes of adaptive blended learning designs to those of traditional classroom teaching practices. The ultimate objective of this effort is to recommend best practices for adaptive, blended learning designs throughout Training Command.

Adaptive Learning

Adaptive learning, also known as adaptive e-learning or adaptive training, is an educational method which uses computer algorithms to deliver customized learning experiences (e.g., feedback, pathways, activities, and resources) to address the unique needs of each learner. Because it employs active, learner-centered approaches (Weimer, 2013) and is tailored to individual learning needs (Bloom, 1984), adaptive learning is capable of offering greater learning effectiveness than other traditional teaching practices, such as lecture. Similarly, adaptive learning has potential to result in efficiencies for formal schools in terms of the time it takes for students to achieve the required proficiency in the topic, and due to its personalized remediation opportunities, the number of instructor hours required to achieve defined learning outcomes.

Adaptation techniques, as discussed in the adaptive learning literature, include: Macro, Micro, Aptitude Treatment Interaction (ATI), and Two-step adaptations (Landsberg et al., 2012; Mödritscher, et al., 2004; Park & Lee, 2003). While macro-adaptation uses prior performance on a pre-test to guide adaptations, micro-adaptation occurs during the learning event, using on-task performance to guide adaptations that support the learner (e.g., feedback, question

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difficulty, etc.). For ATI, the instructional technique or content is adapted based on a learner's aptitudes or abilities. The Two-step adaptive technique combines the Micro and the ATI approaches to initially adapt the learning experience based on aptitudes and abilities, then later adapting by on-task performance during the learning event.

Numerous studies have found that adaptive learning improves the effectiveness and efficiency of learning programs in comparison to non-adaptive teaching approaches (Bond et al., 2019; Despotović-Zrakić et al., 2012; Romero et al., 2006). Bond et al. (2019) conducted an experiment to examine the effectiveness of the Adaptive Perceptual And Cognitive Training System (APACTS), a web-based adaptive learning system that employs a macro-adaptive approach (provided remediation, after completing a knowledge test, on skills that had poor performance), in comparison to a traditional instructional approach to teaching land navigation (standard PowerPoint slides). The Marine students taking the adaptive learning condition experienced significantly higher learning gains compared to the traditional approach in under 2 hr of classroom time. The adaptive group also reported an increased self-efficacy in their understanding of land navigation and perceived ability to transfer their learning into practice. Another study conducted by Despotović-Zrakić et al. (2012) with students taking an e-business course at the University of Belgrade, compared the effectiveness of an adaptive online course (using an ATI approach based on learner preferences and characteristics) to a non-adaptive online course, using the Moodle Learning Management System (LMS). Results indicated that a larger number of students in the adaptive course passed the exam, and those who passed achieved grades that were higher than those in the non-adaptive control group. In a study conducted by Romero et al. (2006), a web-based adaptive training simulator system adapting based on prior performance in previous modules, was introduced to teach cardiopulmonary resuscitation skills to emergency physician students. As a result, students took less time to complete the adaptive condition than students who were in the non-adaptive condition.

Adaptive Blended Learning Environments

Adaptive learning has been employed in studies as a standalone educational program (Bond et al., 2019; Despotović-Zrakić et al., 2012) or as a blended learning strategy to support and enhance the learning experience that happens in a face-to-face classroom setting (Kakosimos, 2015; Sampaio et al., 2011). Garrison and Kanuka (2004) define blended learning as "the thoughtful integration of classroom face-to-face learning experiences with online learning experiences" (p. 96). While adaptive learning focuses on being responsive to individual learner needs, blended learning is concerned with maximizing the learning impact of various learning modalities and settings. Both adaptive learning and blended learning enable students to have some element of control over the time, place, path, or pace of their learning. Many studies have reported higher levels of learning effectiveness for adult learners in blended learning programs in comparison to strictly face-to-face classroom learning environments (Bernard et al., 2014; González-Gómez et al., 2016; Ryan et al., 2016).

Existing studies on the effectiveness of adaptive blended learning interventions for adult learners focus on collecting student performance data from online tasks completed prior to class for the instructor to adapt the class session to learner needs (Howard et al., 2006; Kakosimos, 2015). While this approach has contributed to student learning gains, it does not necessarily create efficiencies for instructor time. Furthermore, studies on the integration of an adaptive learning tool into a course as a blended learning intervention, serve to validate the tool's efficacy by collecting subjective student reaction data (Johnson et al., 2018; Sampaio et al., 2011), opposed to objective data on learning effectiveness (e.g. test scores) or efficiency (e.g. LMS time logs). This literature gap presents an opportunity to study the integration of a self-paced, adaptive learning tool into a course to enhance and create efficiencies for the learning experience during the classroom session and beyond. With the implementation of an adaptive blended learning intervention in a Marine Corps formal school course, the ABLE design team expects to increase the learning achievable in the same period of time, so that instructor-led classroom time can be maximized to focus on higher order learning (see Anderson & Krathwohl, 2001), including concept application, problem solving, and decision making.

THE ADAPTIVE BLENDED LEARNING EXPERIENCE

The Tactical Intelligence Officer Course (TIOC) from the Marine Corps Intelligence School (MCIS) was selected as the testbed for preliminary evaluation. An adaptive Moodle lesson was designed to enable self-paced learning and personalized remediation of foundational Center of Gravity (COG) analysis concepts, so that subsequent instructor-led classroom time can be devoted optimally to advanced practical application exercises. An experimental study design will be applied to test courses to measure learning effectiveness and time efficiency associated with the ABLE intervention of the COG analysis module in comparison to current teaching practice. An experimental preliminary evaluation of the test instruments and adaptive Moodle lesson was conducted with TIOC students as part of this study.

The Tactical Intelligence Officer Course

TIOC is a required eight-week, fully resident course of instructor-led classroom instruction for Lieutenants (O-1) through Captains (O-3) where COG analysis is taught as a module. A COG is defined as "a source of power that provides moral or physical strength, freedom of action, or will to act" (DOD Dictionary of Military and Associated Terms, 2020). A COG analysis would be conducted in combat to identify an adversary's COG and devise a plan to attack it. The objective for the COG analysis module is for students to learn the Marine Corps' COG analysis process and apply it effectively to a historical scenario on a Performance Evaluation Check List (PECL) conducted three days after class time. Traditionally, the COG analysis class has been taught by providing students with pre-work on their Moodle LMS course site the day prior to attending an 8-hr classroom session.

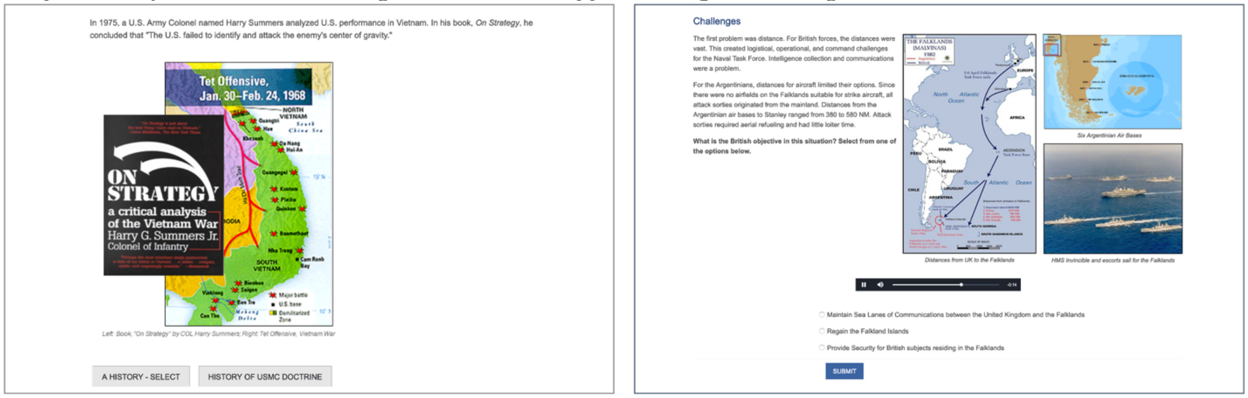
During the class session, foundations of COG analysis and the analysis process are taught in a 2-hr lecture, with the remainder of time spent on instructor-led practical application exercises where students gather in peer groups to apply the COG analysis process to a selection of historical scenarios. Groups then brief the class on their analyses for feedback from the instructor and their peers. While each group applies the same process, they may come to different conclusions on the same case. To assess the viability of the group's COG analysis solution, instructors look for the line of reasoning taken to get the conclusion, not the conclusion itself. They want to see that students understand the COG analysis process and how to apply it. During these practical application exercises, MCIS instructors often take significant time to provide remediation for misconceptions of the definitions of COG analysis terms and steps in the analysis process. With more time instructors could facilitate a deeper dive into more practical application scenarios during class, including current real-world situations. The MCIS objectives for the COG analysis lesson presented a unique opportunity to apply an adaptive blended learning intervention to tailor learning experiences to individual needs, by offering personalized remediation support for foundational concepts and procedures as preparation for interactive participation in instructor-led problem solving and application exercises.

The Center of Gravity Analysis Adaptive Moodle Lesson

An adaptive, self-paced Moodle LMS lesson (an activity type) replaced the typical 2-hr lecture time spent in TIOC on COG analysis foundations. Participants individually completed the lesson on their laptops, and then after a break, rejoined the class to participate in an interactive exercise designed to enable instructors to assess participant learning from the lesson and deconflict gaps in understanding. The remainder of class time involved participants working in small groups on the COG analysis-related practical application exercises.

The development of the Moodle lesson was a collaborative and iterative process between the design team and MCIS academic staff. The design team studied MCIS's COG analysis readings and PowerPoint files used in class to develop an adaptive Moodle lesson that delivered the same foundational content from the lecture portion of the class, along with two historical scenarios to give participants contextual application of the COG analysis process as preparation for class. By transitioning from lecture to a self-paced, adaptive lesson the student learning experience shifts from passive to active enhancing their motivation to learn (Wlodkowsky & Ginsburg, 2017). During the development process, it became apparent to the MCIS COG analysis subject matter expert that much of the foundational content delivered on PowerPoint slides during a lecture was not necessary to prepare students to understand the COG analysis process and application of it. These insights enabled the team to steer away from "data dumping." By focusing on retaining the content that is most critical, more emphasis was provided on opportunities to learn and practice those concepts. The resulting Moodle lesson structure involved the following sections: Sections 1-5 which focused on teaching COG foundational concepts including definitions, history, process, frequently asked questions, and resources; and Sections 6 and 7 which presented two historical practical application scenarios: the Falklands War and Battle of Britain. The lesson included content pages and question pages that required the participant to respond to learning check questions before proceeding. This structure gives the design team the ability to examine the impact of self-paced, adaptive learning for different knowledge types—declarative, procedural, and application. Figure 1 depicts a sample content page from the history section and a question page from the Falklands War practical application section.

Figure 1
Sample History Section Content Page and Practical Application Question Page



For this preliminary iteration, the Moodle lesson is self-paced in that it enables participants to flexibly navigate much of the material. Participants could choose to watch videos or view additional resources to explore the lesson as desired. They could control their navigation through non-linear portions of the lesson, whereby participants may choose a path with less branching (i.e., self-selecting a linear path) or experience the lesson in a more exploratory manner (i.e., clicking on everything). The Moodle lesson also employed a micro-adaptive learning approach based on participant performance on learning check questions. Participants received personalized hints based on their responses and repeated opportunities to attempt responses and receive further remediation. By increasing participant control over the learning experience and providing practice and remedial support to participants, who have not securely grasped the content, we expected to demonstrate learning effectiveness.

Blended Learning Strategy

To effectively blend the individual adaptive learning experience with the collaborative learning experience in the classroom, a Chalk Talk exercise (Smith, 2009) was facilitated after the break. Chalk Talk is a creative alternative to a traditional class discussion that is silent, visual, and promotes equal participation. No one can dominate the discussion or interrupt anyone else, allowing introverts to take time to mull over their thoughts before they respond (Brookfield & Preskill, 2012). The purpose of the Chalk Talk exercise was to enable instructors to assess participant learning from the lesson and help clarify gaps in understanding. On a whiteboard, an instructor wrote the question, “What is the muddiest point for you on Center of Gravity analysis?” with a circle around it. Participants were invited to add their responses with dry erase markers in the space surrounding the circle at their own pace. Participants, along with the instructor, could draw hard or dotted lines between responses where they saw connections. After a suitable period of time had passed (often 5-10 min) and participants seemed satisfied with what was on the board, the instructor facilitated discussion on “the muddiest areas” participants experienced in the lesson to resolve any misconceptions about the material and prepare them to apply their learning to the upcoming practical application exercises.

METHOD

In order to lay the groundwork for measuring learning effectiveness and time efficiency related to blending the adaptive Moodle lesson into MCIS formal school courses, a preliminary evaluation of the instruments and adaptive Moodle lesson was conducted with TIOC students.

Participants

Participants were students of TIOC completing the COG analysis module (21 male; 0 female) aged 26 years on average (M = 26.33, SD = 3.72). The average time spent in their current MOS was less than half a year (M = 0.02, SD = 0.11) with an average time in Service of 3 years in the Marine Corps (M = 2.99, SD = 4.52). Of the 21 participants, the average time spent on formal instruction in COG analysis was less than 1 hr (M = 0.48, SD = 2.18), and none of the participants had conducted COG analysis in the Fleet or a similar non-educational setting.

Materials

The materials used for this preliminary evaluation included the following:

Informed Consent. The participants signed an informed consent form describing the purpose of the study, stating they were participating in the training as volunteers, their inputs were confidential, and they could discontinue participation at any time.

Demographic Form. The demographic form collected the following information: time in service; time in Intelligence MOS; age; number of hours receiving prior training on COG analysis; number of hours applying COG analysis in the Fleet or similar non-educational setting.

Knowledge Test. The knowledge test (KT) is a 25-item test administered before COG analysis instruction and at three separate post COG analysis instruction intervals. It assessed the foundational knowledge about COG analysis including terminology, key concepts, process, and other declarative knowledge required to conduct COG analysis but not applied to a problem set. The knowledge test employed multiple choice and similar item formats.

Application Test. The application test (AT) was administered after COG analysis instruction at three separate intervals. It is scenario-based and uses three MCIS standard, well-established historic cases, one case for each administration. The application test required students to respond to five multiple choice questions to effectively apply each step of the COG analysis process to the case. Among the multiple options provided, only one option correctly demonstrated the best way to apply that step in the process.

Student Reaction Form. The student reaction form, administered to students after COG analysis instruction, obtained Kirkpatrick Level 1 feedback and subjective usability and experience feedback (Kirkpatrick & Kirkpatrick, 2006). Students were required to rate their engagement with the instruction and their perceived learning.

Instructor Evaluation Form. The instructor evaluation form was administered to instructors after the COG analysis learning module and obtained indicators for time efficiencies seen in the classroom. Items on the instructor evaluation form assessed time spent on definitions and terms, procedures for conducting COG analysis, review of historical case studies, and discussions of COG analysis for real-world current events. Additionally, the instructor evaluation form contained items where instructors rated the overall proficiency of the class during COG analysis topic and application portions of classroom instruction.

Student Feedback Form. The student feedback form was administered to students after COG analysis learning module and obtained feedback about the entire student learning experience. Kirkpatrick Level 2 feedback, subjective learning from the lesson, and blended learning experience feedback was collected. Students rated their engagement with the instruction and their perceived learning as well as provide their takeaway on overall understanding given the combination of the adaptive course and the instructor-led class time.

Targeting PECL. At the conclusion of the Targeting module of the course, of which the COG analysis lesson is a component, students were graded on the percentage of PECL items receiving a “yes” rating from instructors during the Targeting culminating exercise.

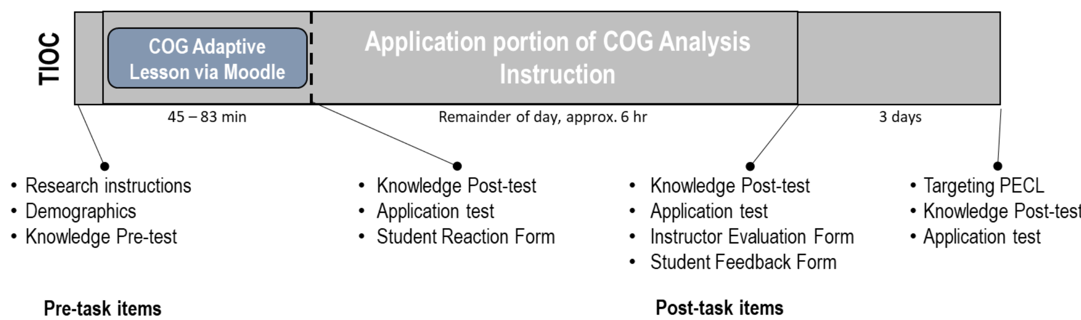
COG Analysis Adaptive Lesson. The COG adaptive lesson is an adaptive lesson developed in Moodle (lesson is an activity type in Moodle), leveraging multi-media assets to deliver an interactive and adaptive COG analysis learning experience.

Procedure

For preliminary evaluation, the objective was to receive student and instructor feedback on the new COG analysis adaptive lesson content and the knowledge and application tests. This feedback will be used to modify the adaptive lesson and assessment instruments used in the experimental test study. Item analysis was conducted on the knowledge and application tests to ensure the reliability of the measures. In addition, the incorporation of preliminary evaluation enables MCIS to determine the best approaches for blending the COG analysis adaptive lesson into their resident courses.

Prior to class, participants completed the informed consent form, the demographic questionnaire, and the knowledge pre-test. After the pre-task items were complete, the participants entered the COG analysis adaptive lesson in Moodle and interacted with the online content. This activity was in lieu of the lecture portion of COG analysis instruction. Once the COG analysis adaptive lesson was completed, the participants took the knowledge post-test, the application test, and responded to the student reaction survey. Following the online portion of the instruction, they participated in the instructor-led application portion of the course. The instructor led a Chalk Talk and then facilitated COG analysis application to historical and real-world examples. At the end of the COG analysis class, students repeated the knowledge post-test, an application post-test, and completed the student feedback form regarding their entire blended learning experience. Finally, at the completion of the entire Targeting annex (COG analysis is an analytic process that supports targeting recommendations), which occurred three days after the COG analysis resident class, participants were graded on the Targeting PECL, then repeated the knowledge post-test and an application post-test. Figure 2 illustrates the schedule of events and items participants completed across time.

Figure 2
Schedule of Events and Measures Taken During TIOC Preliminary Evaluation



ANALYSIS

Knowledge Test Performance Scores

Participants completed the 25-item KT before the COG adaptive lesson in Moodle (KT 1), right after the COG adaptive lesson (KT 2), after the in-class portion of instruction (KT 3), and at the end of the Targeting module (KT 4). The research team conducted a scale reliability analysis for the KT (Cronbach's $\alpha = .80$), indicating all items could remain in the scale for further data analysis. Table 1 reports KT performance scores for each instance.

Table 1
Knowledge Test Descriptive Statistics

Item	*n*	*M*	*M* % Correct	*SD*	Min Correct	Max Correct
Knowledge Test 1(pre-test)	21	13.76	55.05	2.91	8	21
Knowledge Test 2	21	18.00	72.00	2.70	11	22
Knowledge Test 3	21	19.29	77.14	2.47	13	22
Knowledge Test 4	21	19.24	76.95	2.09	15	23

A repeated-measures analysis of variance (ANOVA) on KT scores revealed within-subject effects were statistically significant, $F(3, 60) = 41.86$, $p < .001$, $\eta^2 = .68$, meaning statistically significant differences were present in mean test scores across the four knowledge tests. To assess the differences between each discrete knowledge test, pairwise comparisons were conducted (see Table 2). Between KT 1 and KT 2, $t(18) = -6.24$, $p < .000$, a statistically significant increase was seen in test scores, after participants completed the COG adaptive lesson. This finding provides evidence toward an effective adaptive lesson in providing participants with COG analysis foundational knowledge. Additional statistically significant improvements were seen between KT 2 and KT 3, $t(18) = -2.68$, $p = .014$, pointing to the impact of classroom instruction. Taken together, both the COG adaptive lesson and the classroom instruction, the largest improvement can be seen across test scores KT 1 and KT 3, $t(18) = -8.64$, $p < .000$, suggesting that the blended approach was effective for improving test scores on COG analysis foundational knowledge. It should also be noted that knowledge did not degrade across the 3-day period between KT 3 and KT 4, as indicated by negligible differences in test scores.

Table 2
Paired Samples T-Tests on Mean Knowledge Test Scores

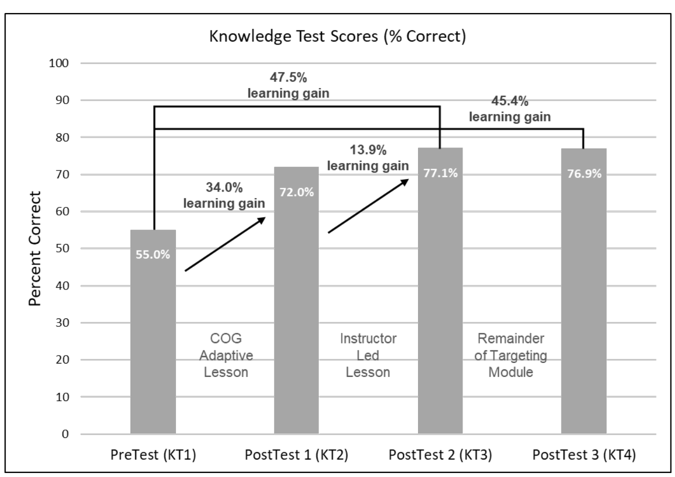
Pair	Variables	*n*	*M*	*SD*	*t*	*df*	*p*	95% CI for Mean Difference	
								Lower	Upper
1	KT 1	21	13.76	2.91	-6.24^{**}	18	.000	-5.66	-2.82
	KT 2	21	18	2.70					
2	KT 1	21	13.76	2.91	-8.64^{**}	18	.000	-6.86	-4.19
	KT 3	21	19.29	2.47					
3	KT 1	21	13.76	2.91	-8.33^{**}	18	.000	-6.85	-4.11
	KT 4	21	19.24	2.07					
4	KT 2	21	18	2.70	-2.68^{*}	18	.014	-2.28	-0.29
	KT 3	21	19.29	2.47					
5	KT 2	21	18	2.70	-2.62^{*}	18	.016	-2.22	-0.25
	KT 4	21	19.24	2.07					
6	KT 3	21	19.29	2.47	0.11	18	.916	-0.88	0.98
	KT 4	21	19.24	2.07					

$^{*}p < .05$, $^{**}p < .01$

Knowledge Test Learning Gains

Across each instance that the KT was administered, learning gain was also assessed (see Figure 3). Learning gain measures actual improvement relative to room for improvement using the formula $\frac{(post-test\ score\ —\ pre-test\ score)}{(total\ questions\ —\ pre-test\ score)}$. Test scores from KT 1 to KT 2 show a 34.0% learning gain, which reflects the improvements seen in percent correct test scores at those administration periods and indicate evidence toward the learning benefits provided by the COG adaptive lesson. There were additional learning gains of 13.9% between KT 2 and KT 3. These two periods of learning gain suggest that participants were able to maximally benefit from the blended learning approach as evidenced by the 47.5% learning gain from KT 1 to KT 3. Learning gain trends seen across time, between KT 1 and KT 4, suggest that participants' learning gain persisted, even after the 3-day period between the COG analysis course and administration of KT 4. In other words, learning gain did not degrade.

Figure 3
Learning Gain Over Time



Application Test

Participants completed an AT at three separate intervals. Prior to participant performance analysis, the research team conducted a scale reliability analysis of each AT. Results indicated that the items did not perform well. Application test results were determined to be insufficient for use in this preliminary evaluation, as five questions used in the test did not prove to be a robust measure. This instrument will be revisited and expanded to 10 questions. Application test scores were excluded from data analysis during this preliminary evaluation.

COG Adaptive Lesson Student Activity Log

The Student Activity Log captured participant metrics within the COG adaptive lesson*,* including time in the lesson in minutes (M = 69.86, SD = 10.65). The minimum time spent in the lesson was 45 min and the longest time in the lesson was 83 min. The time count started when a participant landed on the homepage of the lesson and ended when they clicked the "End Lesson" button after viewing the last page associated with lesson content.

Participant page views were also captured by the system. A page view is the frequency count of navigation to pages within the lesson. At the time of evaluation, the lesson was comprised of 67 unique pages. The frequency count registers navigation to unique pages and pages that have already been seen (e.g., participant goes back a page or answers a learning check question again after an incorrect attempt). Page views provide a total count of all navigation in and across the lesson (M = 97.95, SD = 21.98). The large variability within page views is made possible because of the branching paths in the lesson as well as the ability for participants to retake learning check questions.

COG Adaptive Lesson Learning Check Questions

Thirteen multiple choice questions were included throughout the lesson to gauge student knowledge. They were placed in the COG foundational content (three items), in the Falklands War historical practical application section (five items), and in the Battle of Britain historical practical application section (five items). The totality of these questions scored together provide a participant performance score on the COG adaptive lesson, beyond just a completion metric. The formula for calculating student grade was $\frac{correct\ first\ time\ attempt}{total\ questions} \times 100$. Performance score percent correct across the 13 learning check questions (M = 76.56, SD = 12.98), were extracted via the activity log. When a participant responded correctly to an item, the system allowed the participant to progress forward in the lesson. When a participant responded incorrectly, the participant was given remedial feedback which helped guide the participant toward responding correctly on subsequent attempts. Given participants' responses to learning check questions, item-analysis revealed differences in number of question attempts, suggesting that these items were either justifiably difficult to answer or that the item was a poor indicator of lesson content.

Student Subjective Responses

At two intervals, participants answered questions regarding their experience with the COG adaptive lesson in Moodle (student reaction form) and about their entire blended learning experience after the instructor-led classroom session (student feedback form). Participants responded to the System Usability Scale as part of the student reaction form. Higher ratings on this 5-point Likert scale indicate participants experience subjective usability as better than average/neutral. The reported average System Usability Scale ratings (M = 3.60, SD = 0.71), indicate that participants found the COG adaptive lesson to be useful, usable, and clear. Additionally, ratings of content clarity, consistency, and quality were high (M = 3.65, SD = 0.70). When asked how well certain components in the lesson helped participants gain a clearer understanding of COG analysis and how to apply it, participants rated the Falklands War Practical Application (M = 4.19, SD = 0.60) and the Battle of Britain Practical Application (M = 4.19, SD = 0.60) highest compared to other lesson components. Similarly, when asked how well certain components in the lesson helped participants come prepared and able to apply to the classroom, participants rated the Falklands War Practical Application (M = 4.00, SD = 0.63) highest compared to other lesson components. Other items addressing effectiveness of content, feedback, and guidance from learning check questions and subsequent application to the classroom were also highly rated, (M = 3.76, SD = 0.62).

Instructor-led Classroom Efficiency

Instructor Evaluation Form responses were obtained from two instructors who taught the COG analysis portion of TIOC. They responded to 11 items regarding time spent on certain topics and provided feedback about student learning and use of class time. The instructors facilitated the classroom lesson together, simultaneously, in a 70/30 split. The course was taught over an 8-hr period, of which, time was taken for participants to log in to the COG adaptive lesson. The remainder of the day, approximately 6 hr to 6.5 hr, was left for the two instructors to engage students in the classroom. The main instructor spent a total of approximately 390 min (6.5 hr) teaching in the classroom and the assistant instructor spent a total of approximately 240 min (4 hr) teaching in the classroom. As seen in Table 3, both instructors spent varying amounts of time either lecturing on various COG-related concepts or leading student discussions. Most of the time was spent facilitating historical practical applications.

Table 3
Instructor-Led Class Time Structure

Class Time Item	Main Instructor		Assistant Instructor	
	Minutes	%	*Minutes*	%
Total Time Lecturing/Presenting (COG definitions, examples, process, and use of template)	45	11.54	40	16.67
Total Time Leading Student Discussion (COG definitions, examples, process, and use of template	25	6.41	30	12.50
Total Time Facilitating Practical Applications (historical or current, real-world)	190	48.72	90	37.50
Total Time Providing Feedback or Guidance (implementation, COG process, and use of template)	120	30.77	80	33.33
Addressing Student Questions/Misc.	10	2.56	0	0

Open-ended responses from both instructors revealed that they felt the blended learning approach produced more in-depth discussions during their Chalk Talk exercise where students were more vocal on content areas that needed further explanation, (e.g., "muddy points") and came better prepared to talk about them. Remediation that occurred during the Chalk Talk focused on definitions of COG terms and remediation after the practical application briefings centered on the application of the COG analysis process. These sessions served as a way to correct misunderstandings and address gaps in student knowledge.

DISCUSSION

Findings from this preliminary research provide support for the implementation of an adaptive blended learning intervention into a formal school course for learning effectiveness and efficiency. Learning effectiveness of the ABLE intervention was demonstrated in statistically significant improvements from pre to post test, along with large learning gains. Even after three days, participants showed evidence of marked retention based on their improved KT 4 performance scores. It was in this instance of KT administration, that the floor for the minimum score was elevated (15 out of 25; compared to 8 out of 25 in KT 1) and that the maximum correct score was seen (23 out of 25).

In a shorter amount of time, participants were able to complete the COG adaptive lesson, in lieu of the lecture portion of their class, pointing to preliminary support of improved class time efficiencies. Based on information garnered from a discussion with a MCIS instructor who regularly teaches courses on COG analysis, traditional class time, a lecture on declarative knowledge—terms, definitions, COG analysis process steps—would have taken roughly 2 hr of class time. However, in the preliminary evaluation, participants received lesson content pertaining to terms, definitions, and processes, and *applied* their declarative knowledge to practical application exercises, in less than 2 hr. Preliminary evidence also suggests that content efficiencies and condensed time allocation afforded by the COG adaptive lesson did not negatively impact participant learning or retention as can be seen in the KT performance scores across time.

The use of an adaptive lesson in Moodle supported self-paced, adaptive learning, as individual differences were seen in the student interaction data, along with MajGen Mullen's goal for creating a learner-centered environment. When given the choice, participants selected personalized learning paths that aligned with their specific preferences, suggesting evidence of an effective application of a learner-centered approach. Providing participants with personalized hints and remediation based on individual responses combined with the personalized learning paths, participants indicated positive subjective feedback regarding their experience with the COG adaptive lesson. Even after the entire blended learning experience, participants expressed positive feedback regarding use of class time and their application of concepts learned from the COG adaptive lesson to the classroom. Instructor feedback mirrored participant sentiments; instructors indicated that more effective, fruitful discussions took place beginning at the onset of class time and gaps in participant understanding were addressed efficiently.

Future Directions for Adaptive Blended Learning Designs

Taken together, these findings support implementation and further study of adaptive, blended learning designs in formal schools. The next steps in this research involve applying lessons learned from this preliminary evaluation to experimental testing. Instructor time spent providing participants with remediation during class time was focused on clarifying COG analysis definitions and the steps of the process. To further support participants on upcoming experimental tests, the team intends to include more learning check questions in the definitions and process sections of the adaptive lesson, along with more in-depth adaptations beyond written personalized feedback, such as videos and/or exercises. For the next phase of this study, in addition to the TIOC (a fully resident course), the MAGTF Intelligence Analyst Course (includes a non-resident portion) is also slated for testing. The adaptive COG analysis Moodle lesson will be applied in each course to measure learning effectiveness and time efficiency associated with the ABLE intervention in comparison to current practice (i.e., the control condition). For TIOC, the adaptive lesson will continue to be employed during class time and for the MAGTF Intelligence Analyst Course, it will be completed by students during the non-residency period prior to class time with both online and in-class blended learning strategies employed to ensure effective student retention of learning as preparation for class time. These additional studies will enable us to investigate the effectiveness of adaptive blended learning designs for different student populations and in conjunction with different course configurations.

Adaptive, blended learning interventions can also be employed to enhance learning and create efficiencies in a variety of adult learning settings beyond military training. Both higher education and professional development in the for-profit and non-profit sectors are ripe opportunities for implementation. Based on our preliminary findings and lessons learned, the team offers three recommendations for faculty/trainers in implementing adaptive blended learning designs. First, support and develop faculty to veer away from teacher-centric approaches such as lecture and embrace more active, learner-centered facilitation approaches (i.e., interactive exercises and discussions) during class time. Learner-centric teaching approaches are especially important to facilitate high levels of active participation in the blending and practical application exercises where peer-to-peer learning is critical (Weimer, 2013). Second, when designing an adaptive lesson, less is more. Limit and tailor your content to what is absolutely essential, in order to focus more on developing learning check questions and adaptations for remediation. Third, prior to implementation, clearly communicate learning objectives to students and faculty for the adaptive learning tool and subsequent classroom time. Self-paced adaptive learning can provide a more personalized, efficient way to learn the foundations of a topic, but it does not replace the higher-order learning that can come from applying learning with peers in the classroom. If both faculty and students understand, in advance, that the intent of the lesson is to support student preparation for application in the classroom, that will lead to greater intrinsic motivation and engagement from students during the lesson and classroom time (Wlodkowsky & Ginsburg, 2017).

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