Lessons Learned for Implementing Adaptive Blended Learning Experiences Using Moodle

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ABSTRACT

Adaptive learning is an emerging technology-enabled approach to tailoring learning experience that makes use of computer algorithms to sense and address individual learner needs. Complementing this approach, blended learning integrates online and face-to-face learning experience. Combining these approaches is increasingly prevalent in learning programs due to capabilities to achieve improved learning outcomes and process efficiencies, when compared with traditional classroom approaches to learning experience (Bernard et al., 2014; Bond et al., 2019; González-Gómez et al., 2016). These known benefits presented an opportunity to address institutional challenges in the Marine Corps and other services associated with having to train students under increasing time and personnel resource constraints. The Adaptive Blended Learning Experience (ABLE) effort assessed the outcomes of blending adaptive learning with classroom instruction in a Marine Corps formal school. The purpose of the study was to develop a model to enable learning of Military Occupational Specialty (MOS) related concepts in a self-paced, adaptive format that enhances student learning and creates efficiencies for instructor time.

A Center of Gravity (COG) analysis adaptive Moodle lesson with targeted remediation was developed. A blended learning exercise integrated this Moodle lesson into the Tactical Intelligence Officer Course at the Marine Corps Intelligence Schools (MCIS) so subsequent instructor-led classroom time could concentrate on practical application exercises. An experimental study design measured learning effectiveness using a knowledge test and time efficiency associated with the ABLE intervention in comparison to traditional teaching practices. We expected experimental group participants to learn COG foundational concepts at least as effectively and in less time than the control group, allowing more time for practical application exercises in the classroom. This paper describes the design and implementation process for the ABLE intervention used in experimental testing, participant and instructor feedback, and lessons learned to implement effective, adaptive blended learning course designs using Moodle.

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

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INTRODUCTION

Adaptive learning is an educational method that makes use of computer algorithms to tailor learning experiences to address the unique needs of each learner. This interactive, learner-centered approach puts the learner in the driver seat with opportunities for self-paced navigation and personalized remediation. Adaptive learning tools have been designed to adapt for factors such as incoming learner proficiency or experience, preference for how to receive information, and on-task performance as the learner goes through a lesson (Landsberg et al., 2012; Mödritscher, et al., 2004; Park & Lee, 2003). As a complimentary approach that aims to make the best use of learning modalities, blended learning involves "the thoughtful integration of classroom face-to-face learning experiences with online learning experiences" (Garrison & Kanuka, 2004). Designers of adult learning programs are increasingly combining these methods in courses to enhance and create efficiencies for the student learning experience, in comparison to traditional classroom teaching approaches.

The purpose of the Adaptive Blended Learning Experience (ABLE) effort was to assess the outcomes of self-paced, adaptive learning blended with classroom instruction, and develop a model to facilitate learning of Military Occupational Specialty (MOS) training concepts in a self-paced, adaptive format that enhances student learning and creates efficiencies for instructor time. An online, self-paced adaptive Moodle lesson regarding Center of Gravity (COG) analysis foundational concepts was designed and blended with in-person classroom instruction for the Tactical Intelligence Officer Course (TIOC) at the Marine Corps Intelligence Schools (MCIS) in effort to optimize time spent in the classroom for interactive exercises that develop critical thinking and problem-solving skills.

The outcomes of this effort contributed to developing a framework to integrate effective adaptive blended designs throughout Marine Corps Training Command. The purpose of this paper is to describe the design and implementation process for the adaptive blended learning intervention used in experimental testing, summarize experimental study findings comparing the new approach to traditional teaching practices including feedback from instructor and participant perspectives, and specify lessons learned for future implementation of effective, adaptive blended learning course designs using Moodle.

BACKGROUND

Numerous studies have demonstrated the effectiveness and efficiency of adaptive learning in comparison to non-adaptive teaching approaches (Bond et al., 2019; Despotović-Zrakić et al., 2012; Romero et al., 2006). Blended learning is another educational method that has demonstrated higher learning gains than face-to-face classroom learning environments (Bernard et al., 2014; González-Gómez et al., 2016; Ryan et al., 2016). Studies have examined an adaptive blended learning approach by integrating an adaptive learning tool into a course and have only collected subjective student reaction data (Johnson et al., 2018; Sampaio et al., 2011) to validate the efficacy of the approach, as opposed to collecting objective data on learning effectiveness (e.g., test scores) or efficiency (e.g., Learning Management System (LMS) time logs). This literature gap presented an opportunity to extend the research and development in the areas of adaptive learning and blended learning designs by investigating learning effectiveness

and time efficiency associated with adaptive blended learning in a Training Command formal school context. By implementing an adaptive blended learning intervention in a formal school course, we expected students would successfully learn COG foundational concepts in less time to place more focus on higher order thinking skills such as problem solving and decision making in the classroom (Anderson & Krathwohl, 2001).

AN ADAPTIVE BLENDED LEARNING DESIGN

Course and Topic Selection

Serving as the testbed for this study, TIOC is a required eight-week, fully resident course at MCIS that is attended by Lieutenants (O-1) through Captains (O-3). Our design team worked closely with MCIS's academic staff to select the COG analysis topic, which is taught as a module in TIOC, for blending adaptive learning into a course. 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 is conducted in combat to identify an adversary's COG and devise a plan to attack it. The objective for the COG analysis module at MCIS is for students to learn the Marine Corps COG analysis process and apply it to make targeting recommendations for a historical scenario during a performance evaluation conducted three days after class. For TIOC, the COG analysis module is traditionally taught during an eight-hour instructor-led class where COG foundational concepts are presented in lecture format followed by practical application exercises that students participate in via small groups. Center of Gravity analysis was selected as a topic for our study because students often struggle with learning and applying these concepts, requiring substantial instructor time for remediation in class. To address needs for learning effectiveness and efficiencies to be made for instructor time, our team designed a self-paced adaptive Moodle lesson (AML) on COG analysis foundational concepts along with a blended learning exercise for implementation in TIOC. Moodle is utilized by the USMC as an institutionally supported LMS for formal school courses.

Designing a Self-Paced, Adaptive Moodle Lesson

The first iteration of the AML was developed for application in a preliminary evaluation conducted with a cohort of TIOC students (see Barto et al., 2020). This first iteration featured 67 unique content pages, using existing instructional content and course materials (i.e., MCIS's COG analysis readings, instructor-generated PowerPoint slide decks). Our team collaborated with a subject matter expert instructor to refine existing content in conjunction with MCIS's learning objectives and generate any additional content as needed. Navigation through the content followed either 1) a linear pathway, or 2) an adaptive pathway based on user performance where jumps were triggered from a satisfied condition, e.g., a user answered a question and based on the response, the system navigated to a specified alternate page. The adaptive pathways provided opportunities to include targeted hints based on student responses and repeated opportunities to attempt questions and receive further remediation.

The first iteration of the adaptive lesson contained 13 question pages and seven supplemental pages (i.e., additional resources, bonus content). The question pages were designed to employ a micro-adaptive approach whereby feedback was tailored to the response chosen by the participant (Landsberg et al., 2012). The resulting AML structure included 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 gave us the ability to examine the impact of self-paced, adaptive learning for the different knowledge types: declarative, procedural, and application. Figures 1 and 2 depict a sample content page from the history section and a sample question page from the Falklands War practical application section.

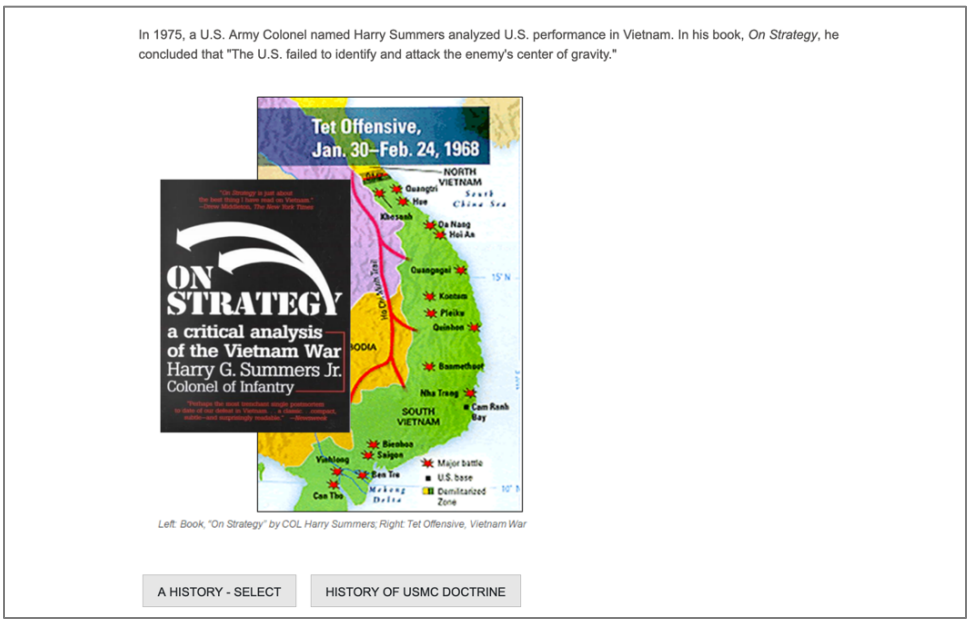

Figure 1. Sample History Section Content Page

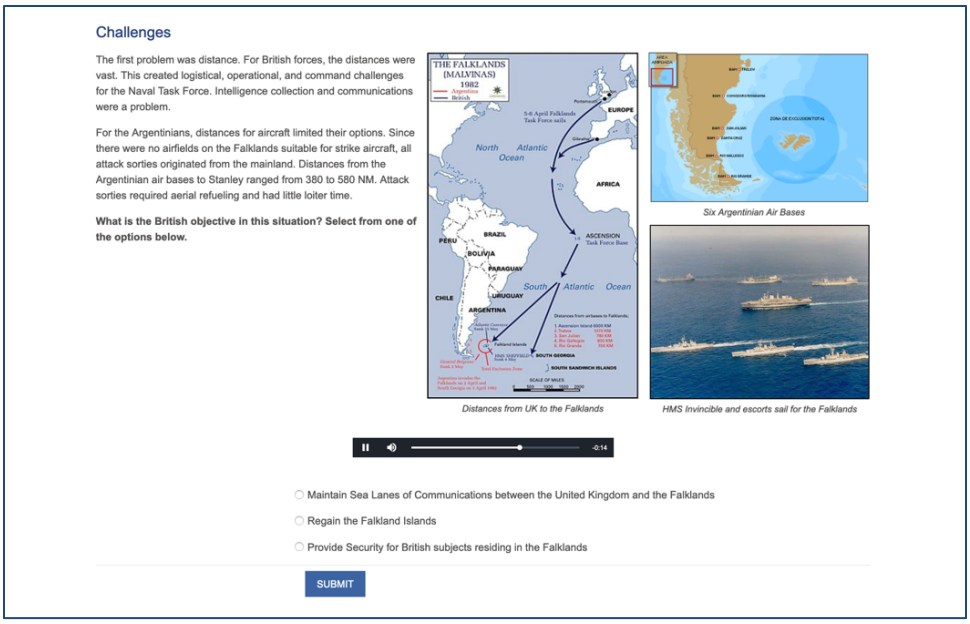

Figure 2. Sample Falklands War Practical Application Question Page

Blended Learning Strategy

To effectively blend the individual adaptive learning experience with the collaborative learning experience in the classroom, a Chalk Talk blended learning exercise (Smith, 2009) was facilitated at the beginning of class time. The purpose of the Chalk Talk was to enable the instructor to assess participant learning from the lesson and help clarify gaps in understanding, resolve any misconceptions about the material, and prepare students to apply their learning to the upcoming practical application exercises. On a whiteboard, the instructor wrote the question, "What is the muddiest point for you on Center of Gravity analysis?" with a circle around it. Participants added their responses with dry erase markers in the space surrounding the circle at their own pace and drew hard or dotted lines between responses where they saw connections along with the instructor. See Figure 3 for Chalk Talk responses to the question about the

"muddiest points" or areas that are unclear. Once participants seemed satisfied with what was on the board, the instructor facilitated discussion about participants' responses.

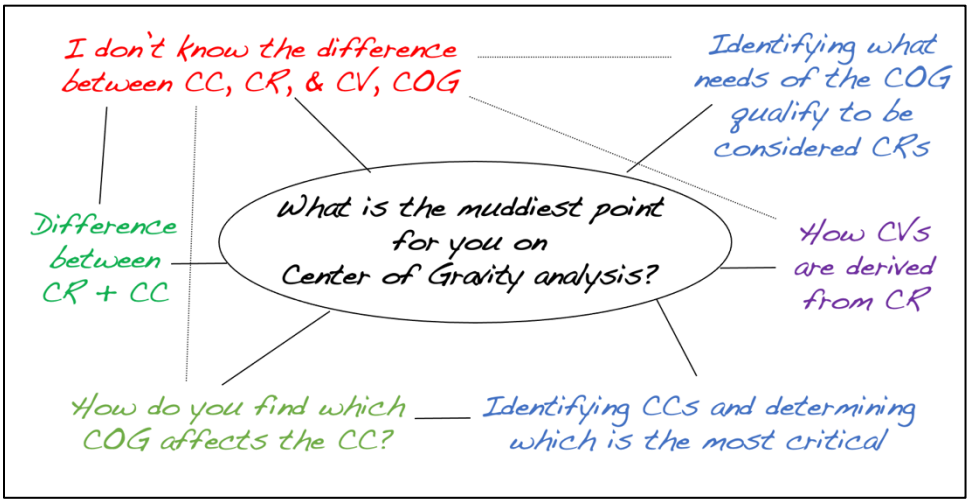

Figure 3. Chalk Talk Responses from Preliminary Evaluation

Instructional Content Updates

The blended learning exercise executed during the class for the preliminary evaluation revealed specific areas in which participants were still struggling or had misunderstandings regarding AML content. A gap analysis was performed on participant responses to Chalk Talk prompts and compared to content from our existing AML. We identified six COG term and process topic areas encompassing 14 total gap items. Gap areas included items regarding overall COG processes, definitions of terms like Critical Capability and Critical Vulnerability, and indicators on how to identify and differentiate COG assets from one another. To address these gap areas, we worked with the subject matter expert instructor to develop targeted learning check questions, response options and their branching pathway behavior, multimedia support, and additional remediation content. The resulting AML iteration used in the experimental study was updated to include 16 additional learning check questions, one infographic, and six informational videos adopted from existing video sources.

In the updated AML, the participants received targeted hints and remedial content based on their responses, followed by an opportunity to apply their new learning by responding to another similar question. Figure 4 depicts a remedial content page based on an incorrect participant response for the Battle of Britain practical application section. By increasing participant control over the learning experience and providing practice and remedial support to participants who have not securely grasped the concepts, we expected to demonstrate learning effectiveness and efficiencies for instructor time.

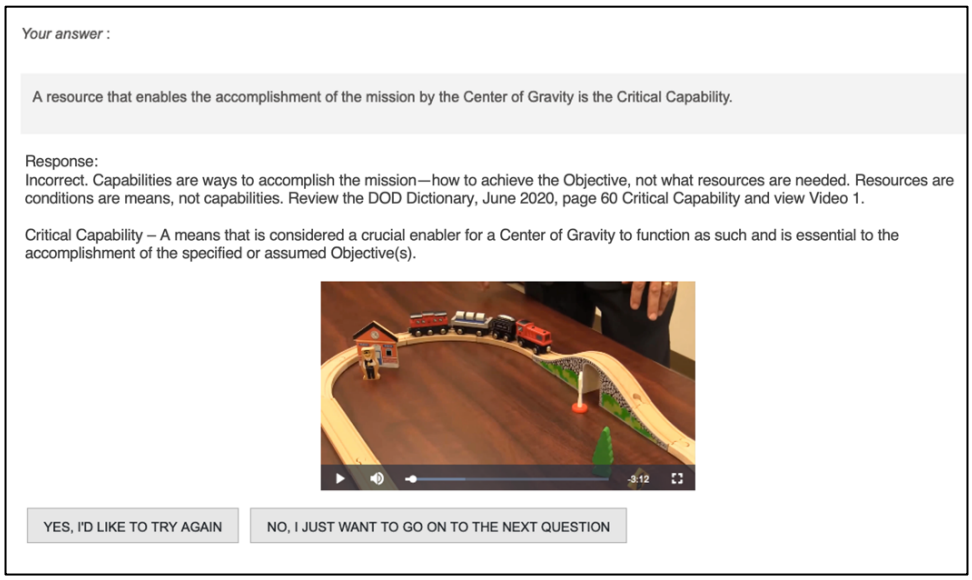

Figure 4. Remedial Content Page from Battle of Britain Practical Application Section

METHOD

An experimental study design was applied in TIOC courses to measure learning effectiveness and time efficiency associated with the adaptive blended learning intervention in comparison to traditional teaching practices.

Participants

Table 1 describes participant demographics for this study.

Table 1. Participant Demographics

	Experimental	Control
n	17	28
Mean age	25.77 (3.29)	26.18 (3.95)
Mean time spent in current MOS (years)	0.15 (0.24)	0.12 (0.19)
Mean time spent in Service (years)	2.44 (2.39)	4.38 (4.93)
Mean time spent on formal instruction in COG analysis (hrs)	5.12 (9.54)	2.89 (3.25)
Mean time spent using COG analysis in the Fleet or a similar non-educational setting (hrs)	4.53 (12.06)	1.71 (3.94)

Note. SD in parenthesis.

The instructor who taught the COG modules for these courses was an expert instructor. He is a retired Marine Corps Lieutenant Colonel with over 30 years of military instruction experience. Prior to participating in our study, he taught the COG analysis topic at MCIS 12 times. In his self-described teaching philosophy, the instructor characterized himself as a learner-centered instructor and dedicated life-long learner.

Materials

The materials used for this study are described below.

Informed Consent. Participants signed an informed consent form describing the purpose of the study, stating participation was voluntary, their inputs were confidential, and they could discontinue participation at any time.

Demographic Form. The demographic form collected information on time in service, time in Intelligence MOS, age,

number of hours receiving prior training on COG analysis, and number of hours applying COG analysis in the Fleet or similar non-educational setting.

Knowledge Test. The knowledge test was a 25-item test that assessed COG analysis foundational knowledge, including terms, key concepts, and the process required to conduct COG analysis but not applied to a problem set. Question types included multiple choice and true/false. The same test was administered at four separate intervals. Participants did not receive feedback on their responses.

Application Test. The application tests were three different scenario-based tests, each using MCIS standard, well-established historic cases. Each application test required students to respond to nine 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. Participants did not receive feedback on their responses.

Student Reaction Form. The student reaction form obtained Kirkpatrick Level 1 feedback and subjective usability and experience feedback (Kirkpatrick & Kirkpatrick, 2006).

Instructor Evaluation Form. The instructor evaluation form asked the instructor to respond to items assessing time spent on definitions and terms, the COG analysis process, historical and current practical application exercises, and the overall proficiency of the student group during class.

Student Feedback Form. The student feedback form obtained Kirkpatrick Level 2 feedback on subjective learning from the lesson and the entire blended learning experience (Kirkpatrick & Kirkpatrick, 2006).

Performance Evaluation Check List (PECL). At the conclusion of the course module that included the COG analysis lesson, students were graded on the percentage of PECL items receiving a "yes" rating from instructors during the culminating exercise.

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

Procedure

The procedure for the experimental and control groups is illustrated in Figure 5. The experimental group, depicted by the orange cells, completed the informed consent form and the demographic questionnaire, the knowledge pre-test, the COG AML, the knowledge post-test and the application test, and then responded to the student reaction survey. They then participated in the Chalk Talk blended learning exercise in preparation for the practical application exercises. Following the remainder of the COG resident instruction, students repeated the knowledge post-test and an application post-test, and completed the student feedback form. Following the completion of the entire Targeting module or ANNEX, students were graded on the Targeting PECL, then repeated the knowledge post-test and an application post-test. The control group followed a similar procedure but did not receive the COG AML. The control group participated in the current, traditional COG course as is. Students in the TIOC control group received the post-test after the lecture portion of instruction and again at the conclusion of the Targeting module/ANNEX.

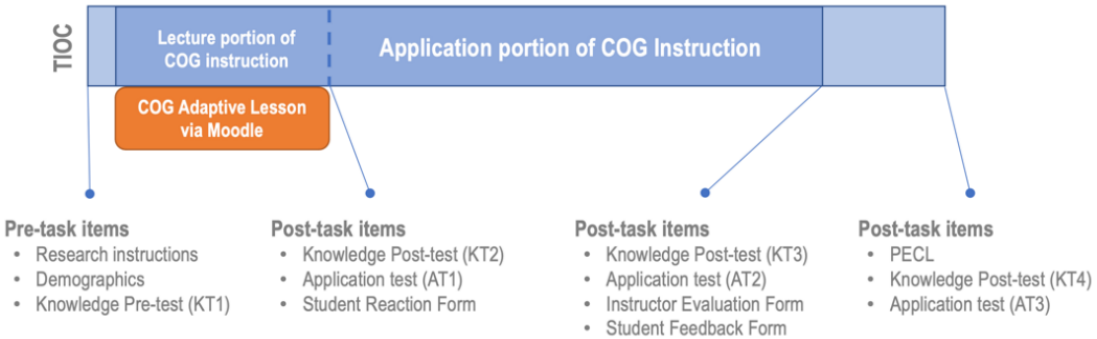

Figure 5. Schedule of Events and Measures Taken During TIOC

ANALYSIS

Learning Effectiveness and Efficiency for the ABLE Intervention

As reported by Barto and Daly (2021), the ABLE intervention produced learning gains that were not different from the traditional instruction, which was led by an instructor who was atypical for this context because he possessed a learner-centric philosophy and background as a highly skilled instructor with thirty years of experience. Greater learning efficiency was also demonstrated for the experimental group, who completed the COG AML in 36.7% less time (minimum time spent in the AML was 32 minutes and the longest time spent was 80 minutes) than the traditional lecture for the control group (90 minutes). In addition, the experimental group conducted five practical application exercises during the instructor-led class as compared to four exercises by the control group.

Participant and Instructor Feedback for the Experimental Group

Because the ABLE intervention demonstrated learning effectiveness at least as well as traditional instruction yet in less time, we turned to student feedback as one source of information from which to derive recommendations for widespread implementation of adaptive blended learning using Moodle. A thematic analysis was conducted on qualitative responses to the subjective Student Reaction Form (completed post-AML) and Student Feedback Form (completed after the entire blended learning experience). Participants in the experimental group provided 537 comments between the reaction form and the feedback form. From the total comments, 412 were grouped into 16 thematic categories (e.g., easy to use, improved understanding, engaging, did not like, confusing, not useful). Of these, 249 (60.4%) comments were positive, 37 (9%) were neutral, and 126 (30.6%) were negative. Many of the positive comments (62%) were made about the usefulness and improved understanding garnered from the adaptive blended learning experience. The major themes derived from qualitative feedback for the experimental group are detailed here along with our interpretations to inform the design and implementation of adaptive blended learning experiences using Moodle in formal school courses.

Feedback on the Adaptive Moodle Lesson

Participants described the foundational content and historical scenarios delivered in the AML as easy to follow, engaging, and useful for learning. With regard to how foundational content was delivered, one participant stated that it "was presented in a logical, linear manner and broken down into useful steps for determining COG." Another spoke about the Falklands War practical application exercise, noting that it "allows [me] to put the concepts to use and shows how it is applied on the battlefield." Many participants also found the visual aids to be engaging and useful for learning, with one participant stating that it "helped paint a picture of the scenario." This feedback makes apparent the importance of *what* content is selected and *how* it is scaffolded during the AML design process to create meaningful learning experiences. Reactions to the audio narration were mixed, providing evidence for the utility of giving students a choice to toggle audio on or off. One participant who provided positive feedback shared, "Having someone read… for you was a great help. Usually I would have to reread something like this several times to truly grasp the content." A few others found the audio to be distracting and redundant, one stating "having the video read what [I] was clearly able to read was distracting." Participant feedback on the use of learning check questions and targeted remediation (including hints, videos, figures) was largely positive and described to be useful for learning. One participant shared that the learning check questions "were a good measure of how well I'd actually absorbed the information" and another noted that "answering questions throughout the course forced me to stay engaged. It told me what I thought incorrectly." Others shared that the targeted feedback and remediation "provided instant clarification" and "allowed me to learn from my mistakes/reinforce why I was right."

Of the negative comments, 65% addressed how certain aspects of the experience were not engaging, not useful, or were confusing. Eight participants (47%) reported that long load times or their computer's lack of audio playback capability caused disengagement and frustration. Comments about the multimedia being not useful or confusing were, by and large, due to technical difficulties. For example, one participant who found the use of audio to not be useful stated that "Moodle is just an unreliable platform for this. Media almost never works or takes so long to load that it becomes a nuisance." Our interpretation of this comment is that Moodle itself may not necessarily be the crux of these issues but use of Moodle and its features could have been hindered by lack of network bandwidth or connection speed,

or hardware issues. Additionally, three participants were unable to complete the COG adaptive lesson and subsequent instruments due to network issues and were removed from all analyses.

Some participants expressed a preference for learning in the classroom and thus having a tendency to become disengaged online. One participant shared that "it helps to actually do this with peers and [the] instructor practically." While it is justified to have a preference for learning in face-to-face classroom settings, the negative attitudes toward the AML could have also been influenced by technical issues and online learning fatigue. The coronavirus pandemic has pushed an increasing amount of virtual interaction and online learning on students of all ages. Regardless of source of the issue, this participant feedback helps make a good case for balancing online learning with classroom learning opportunities through a blended learning environment.

Reactions to the Instructor-led Class Time

All participants provided positive reports of the instructor's facilitation of the instructor-led class time to include the Chalk Talk blended learning exercise and the practical application exercises. They reported that the instructor was well-informed on the subject matter, engaging, clearly communicated, and used thought-provoking questions to facilitate deeper learning. These findings are not surprising and align with the instructor's learner-centric philosophy and background as a highly skilled instructor.

According to the instructor, student discussion during the Chalk Talk was engaging and the exercise lasted longer than originally planned, "Questions were insightful, which meant that the students had fully engaged with the on-line modules prior to class." Some participants also shared that the Chalk Talk was useful for the instructor to mitigate areas of confusion from the lesson prior to participation in practical application exercises, that the instructor "had a very good way of explaining things and making it easy to understand." The exercise was described as enabling "open communication" while it allowed the instructor to "answer … questions regarding content." However, some participants indicated they felt confident in their understanding of COG analysis concepts post-adaptive lesson and would have more actively participated in the exercise if asked a broader question beyond areas that lacked clarity. One participant stated, "Most students had a decent understanding of concepts from the online portion and struggled to identify learning deficiencies."

While the instructor's facilitation of practical application exercises was received positively, and learner engagement was high for both the experimental and control groups, experimental group participants participated in five practical application exercises vice four exercises for the control group. The instructor further commented that for this group "five students remained behind, keenly interested in continuing the conversation." Sustained engagement beyond class time for the experimental group suggests that the adaptive blended learning intervention may have prepared students to engage in deeper, more meaningful learning experiences during the practical application exercises.

DISCUSSION

The results of this study revealed that the ABLE intervention produced greater learning efficiency than an informal lecture conducted by a learner-centered, expert instructor. Students provided positive feedback for the quality of learning experiences (online and during class) in both the experimental and control groups. However, for the experimental group, the instructor reported that student engagement with the COG material continued beyond the designated class time. Negative feedback from the experimental group was largely focused on technical issues with AML, while for the control group critiques were related to overuse of PowerPoint slides or lack of individual pre-work to prepare for class.

Based on lessons learned and outcomes from this study, we recommend the integration of adaptive Moodle lessons into Training Command schools. Training Command can utilize adaptive blended learning interventions to prepare increasing numbers of Marines to develop higher order thinking skills with limited instructors and time available. Potential use of freed up instructor time could allow for increased capacity to train more students simultaneously with block scheduling. We offer the following recommendations to support Marine Corps schools and other institutions to design and implement adaptive blended learning interventions using Moodle, and other platforms with adaptive learning capabilities, in their courses.

Designing an AML

1. ***Design Roles.*** Roles needed to design an AML include a chief instructor or course director with in-depth knowledge on the subject matter being taught, and an instructional designer skilled at designing learning experiences in Moodle. These roles may be filled by separate individuals in collaboration or the same person. However, it is ideal that those involved in the AML creation process bring a learner-centered perspective that embraces interactive and experiential approaches to facilitating adult learning (Weimer, 2013).

2. ***Concept Selection.*** Select concepts from courses that are already using Moodle as their LMS. Students who are accustomed to using Moodle for accessing course resources, activities, and assignments will experience limited hurdles when using an adaptive lesson activity. Types of knowledge suitable for an AML include *declarative* (identifying and understanding terms), *procedural* (identifying and understanding steps of a process), and *application knowledge* (application of terms or process to a given context). An AML is appropriate for reaching the *remember, understand*, and *apply* levels of Bloom's Taxonomy (Anderson & Krathwohl, 2001), which helps optimize time spent in the classroom for interactive exercises that focus on the *analyze*, *evaluate*, and *create* levels.

3. ***Content Selection.*** Once you identify concepts to be taught, plan your lesson by scaffolding content into sections determined by the learning objectives. Use content (text, imagery) derived from teaching materials that you would use in your classroom lecture for the AML. Determine the content most critical to accomplishing your learning objectives, and limit and tailor this to what is essential, placing greater emphasis on learning of concepts than content delivery (Weimer, 2013).

4. ***Learning Check Questions.*** For each AML section, include learning check questions targeted to achieving your learning objectives for that section (Bae et al. 2019; Taylor et al. 2021). Question pages can be added to the end of the section. However, if you intend to question a student throughout a practical application scenario, integrate question pages throughout. For question types, true/false questions can work, but multiple-choice format is ideal to provide sufficient remediation opportunities.

5. ***Remediation Opportunities.*** Moodle allows for a micro approach to adaptive learning for lessons. Pilot an AML that provides targeted feedback based on how students respond to learning check questions. Then, use student responses from the blended learning exercise to better understand the areas with which students are struggling in the AML. If it is determined that more remedial support is needed, update the AML for future use by adding additional instructional content to supplement targeted feedback followed by another similar type of question.

Implementing an Adaptive Blended Learning Design

6. ***Faculty and Designer Engagement.*** Designing an AML requires more time up front to develop a lesson but pays dividends once developed by freeing up instructor time during all subsequent courses. The development process can be supported by providing the additional resources (i.e., time and people) to make the initial investment. In addition to providing resource support, instructors and designers can become receptive to this process if they understand how it benefits them as well as the students. Explain the use of adaptive blended learning experiences to optimize classroom time for exercises that are more dependent on peer learning and focus on higher-order thinking skills. One AML can be utilized for multiple instructors, classes, or courses, making good mileage off of the initial upfront time commitment. Instructor and designer engagement in the AML development process will also help obtain their buy-in (Deluca, 1999).

7. ***Student Engagement.*** To avoid online learning fatigue and make the best use of student and instructor time, we advise implementing a flipped classroom model, a blended learning model capable of enhancing student satisfaction, engagement, and motivation (Akçayır & Akçayır, 2018; Bösner et al., 2015; Huang & Hong, 2016; Khanova et al., 2015). Students complete the AML on their own and arrive in class prepared to apply what they learned in interactive and collaborative learning experiences with their peers. Students are engaged prior to class by the flexibility offered to complete the lesson on their own time, the interactive design of the lesson, and the ability to receive personalized remediation as needed. Communicate to students in advance the rationale of using an adaptive blended learning experience to prepare them to optimize their use of class

time. Students will likely appreciate hearing that adaptive learning will not replace their classroom learning experience, but should help to enhance it (Brookfield, 2015; Wlodkowsky & Ginsburg, 2017).

8. ***Technical Logistics.*** Invest in the IT infrastructure that will support high levels of traffic across subordinate commands or institutions. This investment will ensure that students have the proper network bandwidth to complete a Moodle lesson that includes interactive and multimedia components. Ensure students have the proper hardware on their laptops, including speakers, to fully experience multimedia features.

9. ***Support for Self-Directed Learning.*** Students will complete the AML on their own time while working their day jobs, completing other academic work, and navigating home life. To mitigate learning barriers that can be created from those competing commitments (see Cross, 1981), provide students with structure and guidance to support the completion of self-paced online assignments. Offer guidance on creating a quiet, non-distracting space to work and estimated maximum timeframes they should allow for completing the AML, as well as other self-paced online assignments.

10. ***Blended Learning Exercise Design.*** Design an interactive blended learning exercise to focus on soliciting and discussing student responses to key learning takeaways and areas that are unclear. We recommend facilitating a modified Chalk Talk exercise using two white boards or large Post-It notes with each question on a different white board/Post-It note, or a Newsprint Dialogue exercise (see Brookfield & Preskill, 2012) with each question on its own poster.

Future Research Directions

The ABLE study enabled us to compare an adaptive blended learning intervention with traditional teaching practices during a fully resident course, yet research is still needed to determine the outcomes of implementing an adaptive blended learning experience using Moodle in other course configurations, such as courses with non-resident portions. Additional work is required to determine the most effective means of implementing non-resident Moodle lessons, adaptive or otherwise, in advance of resident instruction. The control and experimental groups did not perform significantly differently on the first and second application tests, suggesting adaptive learning is similarly effective as traditional instruction for application knowledge. However, a limitation of this research is that it did not discern whether adaptive blended learning can support application knowledge as effectively as declarative and procedural knowledge. Learning and retention of application knowledge gained from adaptive blended learning requires further study.

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