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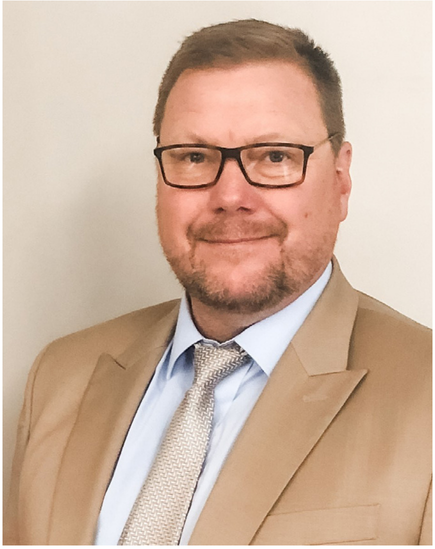

Steven A. Petersen, EdD
Journal of Military Learning
Editor in Chief

Welcome to the October 2024 edition of the *Journal of Military Learning* (*JML*). This edition includes manuscripts from authors representing the U.S. Marine Corps, the U.S. Air Force Academy, Johns Hopkins University, and the U.S. Naval War College. The topics cover leveraging formative assessments to improve student learning outcomes, experimental and collaborative approaches to large animal training for U.S. Army Veterinary Services soldiers in Europe, transformative learning in the military through Force Design 2030, and an analysis of demographics and experiential interactions in general education courses at the U.S. Air Force Academy and their impact on STEM attrition. I hope you enjoy this selection of articles and encourage all our readers to submit manuscripts for a future edition's consideration.

JML will publish a conference edition of select manuscripts presented at the Army University Learning Symposium 2024 (AULS 2024), which was hosted by Army University across two sessions in June 2024. The overall theme for the symposium was Artificial Intelligence Applications for Learning. AULS 2024 brought over 500 educators, researchers, instructional designers, and curriculum developers together to discuss best practices in and issues surrounding the four main topics of the AULS 2024: learning organizations, learning science and technologies, learning data, and learning strategies—transfer of learning. Look for the special conference edition in February 2025.

Finally, I'd like to announce starting with the February 2025 *JML* conference edition, Dr. Audrey Ayers, Army University, will be assuming the role as chief editor. I accepted the role of chief editor one year ago with the intent to serve in this capacity for three years. However, I've since been given a new opportunity that will not afford me the luxury of continuing to serve as *JML*'s chief editor. It has been my great pleasure serving as chief editor over the last year, and I thank all who have contributed manuscripts, who served on the editorial board or as associate editors, and the Army University Press for making the *JML* successful.

The *JML* brings current adult-learning discussions and educational research from the military and civilian fields for continuous improvements in learning. Only through critical thinking and challenging our education paradigms can we as a learning organization fully reexamine and assess opportunities to improve our military education. The *JML* is published each April and October. A detailed call for papers and manuscript submission guidelines are found at https://www.armyupress.army.mil/Journals/Journal-of-Military-Learning.

Peer Reviewed

Leveraging Formative Assessments to Improve Student Outcomes

Lessons Learned

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Abstract

Formative assessments are an effective, if underutilized, way to improve student learning outcomes. Nevertheless, not all formative assessments are the same. This study examines peer review as a formative assessment and the impact on student learning outcomes. The study also looks at the effectiveness of formative assessments in improving student writing skills in a graduate program.

In the past, education at the United States Army War College (USAWC) relied on an instructor-centered model in which teachers transmit information to students (Spooner, 2015). Recently, researchers and practitioners have recommended a shift to student-centered learning (Blumberg, 2009). A key component of student-centered learning is frequent feedback opportunities via formative assessments (Gikandi et al., 2011). Formative assessments occur throughout a course and provide both students and faculty information about learning as it happens (Kelley et al., 2019; Spooner, 2015). This article utilizes a mixed-method approach to examine the impact of using peer review as a formative assessment of student learning outcomes in a graduate-level distance education course at the USAWC.

Background and Literature Review

The USAWC's mission is to promote senior leader development. The War College consists of a resident and distance program accredited by the chairman of the Joint Chiefs of Staff (through the process for accreditation of joint education) and the Middle

States Commission on Higher Education. In the distance program, seminars include up to thirty students with one or two faculty members serving as mentors and evaluators. In the first year of studies, a pool of faculty members evaluates student papers. Therefore, a student will have a different faculty member grade their papers in each course, which allows students to get feedback from multiple faculty members. In the second year of the program, faculty members only evaluate students in their seminar.[1]

The college has recently increased its emphasis on formative assessments as a method for applying evidence-based teaching methods and utilizing data to make decisions. According to the college's memorandum on student assessment, "formative events allow students to gauge their understanding of new material as well as learn and practice new skills" (Breckenridge, 2020, p. 3). The memorandum encourages faculty members to provide feedback to students on drafts and outlines before submission for grading.

While the assessment policy acknowledges the role of students "in assessment, critique, and feedback," the memo does not explicitly address peer feedback (Breckenridge, 2020, p. 3). Given the level of experience and expertise of the adult learners in the program, a peer-review process seems like a valuable method for increasing the amount of feedback that students receive without increasing the burden on students or faculty with respect to time. The following sections describe the findings from the literature on peer feedback and its impact on learning outcomes and student writing.

Peer Feedback Has the Potential to Improve Learning Outcomes

The new assessment policy is consistent with research findings, which have found that formative assessments contribute to improved student outcomes and higher teaching quality (Bakula, 2010; Cauley & McMillan, 2010; Cizek, 2010; Petrović et al., 2017). A recent meta-analysis of 54 studies examining learning outcomes found that peer reviews improve academic performance (Double et al., 2020). Student and teacher perceptions also support the use of peer feedback (Brown et al., 2009; Kaufman & Schunn, 2010; Young & Jackman, 2014).

Peer Feedback Has the Potential to Improve Students' Writing

In addition to improving achievement of specific learning outcomes, research indicates that peer reviews can improve student writing (Ibarra-Sáiz et al., 2020; Mirick, 2020; Samarasekara et al., 2020; Wood, 2022). Multipeer feedback has a greater effect on writing than receiving feedback from an expert or just a single peer (Cho &

[1] Note: This process has changed since the study was first conducted. Now faculty members only evaluate students in their seminar in the first and second years of the program.

Schunn, 2007, p. 15). Additionally, requiring students to make evaluative comments on other student products improves writing more than providing a rating alone (Wooley et al., 2008, p. 2377). Furthermore, by "analyzing other students' strengths and weaknesses, readers/reviewers become better at recognizing and addressing their own weaknesses" (Ambrose et al., 2010, p. 258). Surprisingly, the value of peer reviews does not appear to depend solely on reviewing superior student products. Peer reviews are more effective when they expose students to both good and bad examples (Zong et al., 2020).

Based on the benefits described in the literature, the USAWC began to incorporate peer feedback as part of its formative assessments. Since the institutional policy does not specify a particular approach, the faculty could experiment with peer reviews in the curriculum. The following sections describe faculty formative assessments and the peer-review process in one course at the USAWC.

Faculty Formative Assessments (Mentoring) at the USAWC

Since at least 2007, the department's mentoring program provided formative feedback to students who struggled during the first few courses in the distance program. In this program, faculty members provided additional assistance to students who failed the diagnostic essays during orientation or failed to achieve a satisfactory outcome (e.g., scored below a B) on a graded course. These students could voluntarily submit an outline for each writing requirement. Faculty would review the outline and provide narrative comments to the students to help them improve the content and organization of their ideas. The students would then have at least one week to review and incorporate the feedback into the final submission. They could also talk to the faculty who provided the comments for clarification. The course director developed a guide for faculty that included details on answering the questions and a

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standard rubric for evaluating student submissions. The course director also conducted a training session to calibrate faculty on the standards to achieve the desired learning outcomes. This program has always been purely voluntary, and there has never been a requirement for students to participate.

Peer Formative Assessments (Peer Feedback) at the USAWC

In the past two years, faculty have experimented with using peer feedback and faculty feedback to improve student learning outcomes and student writing. Since most students struggle with answering the question prompts and organizing their thoughts, the program decided to focus formative assessments on student outlines rather than draft papers in accordance with the USAWC assessment policy (Breckenridge, 2020). At first, the department used a blog or discussion board features of Blackboard for peer reviews. Subsequently, the department employed an online tool designed to facilitate peer feedback, Peerceptiv. Peerceptiv reduced the administrative burden of implementing a peer-review process. The distance program decided to utilize a double-anonymized system, where both the original author and the reviewers remain anonymous. This system reduced the potential for bias and encouraged more honest critical feedback.

It was clear from the initial planning stages that "in order for students to be able to engage in this process effectively, the reviewers need a structure to guide their reading and feedback, the writers need reviews from several readers, and the writers need sufficient time to implement feedback and revise their work" (Ambrose et al., 2010, p. 257). Therefore, the program developed a peer-review process that followed the approach outlined in Ambrose et al.

Structure to Guide Peer Reviews

The course director instituted three strategies to guide peer reviews. First, he developed an instructor guide and a rubric, which included numerical ratings using a Likert scale and narrative comments on each assignment element. He later conducted a training session to teach students how to navigate the peer feedback process and provide useful feedback. Finally, the course director recorded the session for students unable to participate synchronously. Table 1 provides an example of the peer-review prompt.

The Three-Stage Process and Adequate Time

The program developed a three-stage peer-review process to be consistent with a previous study on peer review (Ambrose et al., 2010). In the first stage of the peer-review process, students uploaded outlines in Peerceptiv. In the second stage, students

Table 1
Sample Peer Review Prompt

SCORE	DESCRIPTION
5	The thesis and essay map are complete and clearly outlined and implemented.
4	Between 3 and 5.
3	The thesis and essay map are mostly clear.
2	Between a 1 and 3.
1	The position is vague. The organization of the argument is missing, unclear, or incomplete.

Note: Rate the thesis and essay map in the introduction of this essay. Briefly expand upon your rating of the introduction.

had three days to review other student outlines. Each student evaluated two or three outlines during this period. After completing their final review, students could access their feedback. Again, these were double-anonymized reviews, so students did not know whose outlines they were evaluating, nor did they know who provided comments to them. After seeing the feedback, students gave feedback on the clarity and usefulness of the comments they received. Reviewers could then access this feedback to help them improve their peer-review skills.

In the third and final stage of the peer-review process, students had about a week to incorporate the feedback they received into their papers before submitting the completed assignment. Because the use of peer feedback was new in the program, this study represents the first formal assessment of the effectiveness of the peer-review process at the USAWC.

Based on the literature above, this mixed-method study tested the following hypotheses to determine the effectiveness of the implementation of the peer-review process as a formative assessment:

- H1: Students are satisfied with the peer-feedback process.
- H2: Participation in peer feedback improves student outcomes (grades).
- H3: Participation in formative assessments has an enduring impact on writing skills in subsequent courses, as evidenced by fewer failures.

Methods

This study used a mixed-methods approach to evaluate these hypotheses. The USAWC Institutional Review Board approved the research design. The data included quantitative data on student grades and qualitative reflections from the students via surveys.

To test the first hypothesis, the authors analyzed the results from student surveys to determine students' views of formative assessments. To test the second hypothesis, the authors compared course results to previous years (percentage of failures and grades). The authors used grades from the first two core courses (Strategic Leadership–DE2301 and National Security Policy and Strategy–DE2302) for comparison. Every student completed the summative assessments in DE2301; formative assessments (both mentoring and peer review) were voluntary in DE2302. Unlike the USAWC resident program, a different faculty member conducted the summative and the formative assessments in these courses.

To test the final hypothesis, the authors compared the course results (percentage of failures and grades) of participants and nonparticipants in the peer-review process in subsequent courses (War and Military Strategy–DE2303 and Global and Regional Issues–DE2304; see Appendix A for course descriptions).

Because the survey examines data across multiple years, it is important to note that the student cohort composition in the distance education program was similar from academic year (AY) 19 through AY24. Most students are military colonels or lieutenant colonels and in either the Army National Guard or Army Reserve. The gender ratios also remained constant. Thus, there were no significant demographic changes before and after the course director introduced peer reviews.

Results

H1: Students are satisfied with the peer feedback.

Results from the student surveys suggested that students were satisfied with the peer-review process; 96% of students were satisfied or very satisfied with faculty feedback and 73% with peer feedback. Students also had the chance to rate the feedback they received in Peerceptiv, on a scale from 1 to 5, based on how helpful that feedback was. Most students (93%) rated their feedback as helpful at a three or higher level, with five being the highest grade. These results are consistent with other previously mentioned studies on peer feedback (Brown et al., 2009; Kaufman & Schunn, 2010; Young & Jackman, 2014).

Descriptive comments suggested that the peer-review process helped students identify gaps in their approaches to the questions and sharpen the focus of their arguments. The following end-of-course survey comments were reflective of sentiments supporting peer reviews:

> I (appreciated) the opportunity to review other essays and work to provide productive feedback to my peers. Critically reviewing other essays assisted me to be more critical in reviewing my work.

Table 2
Change in Grades Over the Past Six Years

Academic Year (AY)	Total High Pass/Course Participants	High Pass (%)
AY19	88/398	22.1%
AY20	81/417	19.4%
AY21	107/402	26.6%
AY22	85/401	21.2%

> It was a useful tool and receiving peer feedback helped to see different perspectives from the other students. I found it very valuable.

Comments that were skeptical of the peer-review process centered around concerns about the "blind leading the blind" and the varying quality of peer feedback. In some cases, the feedback was neither specific nor constructive. There were also instances where one set of feedback contradicted another.

H2: Participation in faculty and peer feedback improves student outcomes (grades).

Results suggested that faculty and peer formative assessments positively impacted student learning outcomes as measured by course grades. In the first two years of incorporating faculty and peer formative assessments in DE2302 (AY23 and AY24), excellent grades (A- and above) increased from 21% to 43% of student summative assessments and failure rates dropped from a four-year average of 12.4% (from AY19 to AY22) to an average of 7.4% (from AY23 to AY24). About 58% of students participated in the voluntary formative assessments in AY23 and AY24.

Rates of high passing (grades of A and A+) increased significantly in DE2302 from the period AY19 to AY22 (before peer feedback) to the period AY23 to AY24 (after peer feedback) (see Table 2).

The authors used a logistic regression equation to evaluate individual student outcomes in DE2302. The independent variables were grades in DE2301 (high pass, pass, or fail) to account for student potential before formative assessment; participation in Peerceptiv (yes or no) to account for the impact of peer feedback; and participation in mentoring (yes or no) to account for the effect of faculty feedback. The dependent variable was the student grade in DE2302 (high pass versus low pass and fail).

The result using these variables was not statistically significant (McFadden $\mathcal{R}^2$ = .01, X^2 [3] = 6.7, p =.08). Participating in mentoring was the only statistically significant predictor β = 1.5, $p = .006$. When participating in mentoring (i.e., going from 0 to 1), the odds of achieving a high pass grade versus the combination of the other two grade categories are 4.4 times greater when holding the other variables in the model constant. When participating in Peerceptiv (i.e., going from 0 to 1), the odds of achieving a high pass grade decreased slightly, to 0.7 (See Table 3). However, we cannot rule out random error when interpreting the results because participating in Peerceptiv was not statistically significant. These results were also robust using other statistical analyses (see Appendix B).

H3: Participation in formative assessments has an enduring impact on writing skills in subsequent courses, as evidenced by fewer failures.

Finally, the authors compared course grades (DE2301 to DE2304) before and after the course director introduced peer reviews in AY23 to see if they led to any changes in the number of failures. Table 4 contains the results from the past six years.

Average failure rates dropped significantly in DE2302 in AY23 and AY24 (after the introduction of peer reviews) from the average in the period AY19 to AY22. (The spike in failure rates in AY22 appears to have been the result of a poorly worded essay prompt.) The proportion of participants who failed DE2302 differed across years, X^2 (5, $\mathcal{N}$ = 2424) = 26.9, $p < .0001$. The number of failures was fewer than expected based on historical trends in AY23 (expected 41.8, actual 25) and AY24 (expected 44.6, actual 35).

While failure rates dropped in DE2302 after the introduction of peer reviews, the failure rates increased significantly in DE2303. Most of that increase occurred between AY22 and AY24. This suggests that any positive impact of peer feedback did not persist in the following course. There was also not a significant relationship between academic year and failure rates in DE2304 X^2 (5, $\mathcal{N}$ = 2333) = 3.36, $p = .645$.

Discussion

H1: Students are satisfied with the peer feedback.

The analysis provided support for the first hypothesis and indicated that students found that receiving peer feedback was valuable. This result was consistent with the previously cited literature. The three-stage peer-review process employed by the course director was consistent with other studies on peer review (Ambrose et al., 2010) and took advantage of an innovative software application (Peerceptiv) to smoothly administer and complete reviews. Given the time limitations of faculty and students, the positive reaction to peer reviews from most students was an important

Table 3
Odds Ratio from Logistic Regression Model to Predict Grade in DE2302

	Odds Ratio	Lower	Upper
Peerceptiv participation	0.7	0.5	1.1
Mentoring participation	4.4	1.5	12.7
Fail vs. High Pass in DE2301	1.1	0.5	2.3
Pass vs. High Pass in DE2301	0.7	0.4	1.0

finding. Faculty also expressed satisfaction with the peer-review process in course after action reviews. That said, course directors could make improvements to the structure of the process to address concerns expressed in the student surveys.

First, the course directors can increase emphasis on how to conduct peer reviews (Sanchez, 2019) and how to integrate feedback into their work. Providing examples of feedback on both strong and poor submissions could increase both the quality of the peer reviews and subsequent student performance (Verleger et al., 2016). Second, a rehearsal using the actual rubrics and sample products might also improve student feedback. This could include practice evaluations and faculty feedback to students during the practice sessions. Third, course directors could monitor the results more closely to ensure that every student receives multiple reviews. Many negative survey comments pointed to only receiving two of the three promised peer reviews. Changing the settings or due dates in Peerceptiv could remedy this issue. As a fail-safe, faculty members could provide the third review where necessary. Finally, faculty can present research findings to students that explain the benefits of the peer-review process. Doing this at the beginning of the program could preempt the "blind-leading-the-blind" comments discussed earlier. For example, Wu & Schunn (2020) analyzed the quality of feedback provided in peer reviews and found that low-quality feedback was infrequent. Providing students with this study and other research on the benefits of the peer-review process (e.g., Double et al., 2020; Ibarra-Sáiz et al., 2020; Mirick, 2020; Samarasekara et al., 2020; Wood, 2022) should "allay concerns about the blind-leading-the-blind in peer feedback" (Wu & Schunn, 2020, p. 1).

H2: Participation in peer feedback improves student outcomes (grades).

The implementation of peer reviews increased the number of high pass grades and reduced the number of failures within DE2302 from an average of 12.4% (AY19 to AY22) to 7.4% (from AY23 to AY24). This result suggests that there were benefits to student performance in DE2302. However, when controlling for prior grades and

Table 4
Course Failures and Resubmission Raters

	DE2302		DE2303		DE2304	
AY	**Total failures/ Total students**	**RESUB RATE (%)**	**Total failures/ Total students**	**RESUB RATE (%)**	**Total failures/ Total students**	**RESUB RATE (%)**
AY19	47/398	11.8%	42/390	10.8%	68/386	17.6%
AY20	45/417	10.8%	51/407	12.5%	81/404	20.0%
AY21	40/402	10.0%	36/393	9.2%	81/390	20.8%
AY22	68/401	17.0%	59/389	15.2%	78/383	20.4%
AY23*	25/390	6.4%	64/375	17.1%	79/367	21.5%
AY24*	35/416	8.4%	68/404	16.8%	71/403	17.6%

Note: * Indicates when peer reviews started in DE2302

participation in faculty mentoring, the results did not indicate that participating in the peer-review process could predict a final grade. This result was surprising, especially considering the literature on the positive impact of peer reviews on student outcomes (Bakula, 2010; Cauley & McMillan, 2010; Cizek, 2010; Deiglmayr, 2018; Double et al., 2020; Petrović et al., 2017).

There are plausible explanations for the result. The limited impact on student performance could be related to a lack of trust in their peers' feedback. Some of this sentiment came out in student surveys. Successful peer review requires students to trust their judgment and the judgment of their peers (Ibarra-Sáiz et al., 2020, p. 140). The recommendations in H1 to improve student satisfaction with peer feedback should also improve student outcomes.

H3: Participation in formative assessments has an enduring impact on writing skills in subsequent courses, as evidenced by fewer failures.

While the average failure rates in DE2302 decreased in the two years with peer reviews (AY23 and AY24), the positive impact did not persist in subsequent courses. Failure rates were worse in DE2303 in AY23 and AY24 and did not change significantly in DE2304 during this period. This result was surprising given the previously cited literature linking peer feedback and improved learning outcomes (Ibarra-Sáiz et al., 2020; Mirick, 2020; Samarasekara et al., 2020; Wood, 2022).

There are several possible explanations for this finding. Multiple institutional policies might have interacted to impact this result. First, the college increased its overall emphasis on writing in AY23 and AY24 and thereby increased the standards expected of students. This certainly resulted in more critical evaluations and may have improved student writing. Second, the course director reduced the number of written requirements from three short essays from AY19 to AY22 (600 words each) to two short essays in AY23 and AY24 (750 words each). This gave students fewer chances to improve their grades over multiple assignments. Finally, the course director added a dedicated writing preparation week to DE2302 before the summative assessment in AY23 and AY24 to enable students to review and incorporate both faculty and peer feedback. Other courses (DE2301, DE2303, or DE2304) did not include dedicated writing weeks. Unfortunately, these changes coincided with the implementation of the peer-review process adding several confounding variables to the study.

Limitations and Peer Feedback Training

There are two main limitations of this study. First, some programs require a standardized test (GRE or GMAT) or a graduate skills diagnostic test for student admissions. This program does not. Each service component holds a board that selects students for enrollment based on a review of past performance in the student's field and the student's potential for future service, but there is no requirement for a graduate skills test. However, students may participate in an orientation program that includes a diagnostic essay. Based on the diagnostic essay results, students may enroll in an additional writing assistance program before the first credit-granting course begins. Since not every student participates in the diagnostic essay program, it is not practical to use this as a control variable for student writing ability.

Second, as described in the previous section, the study occurred in conjunction with several other policy changes at the USAWC. The other policy changes could have impacted the metrics of student learning and skill development. Similarly, parts of the study occurred during the height of the COVID-19 pandemic. While the pandemic did not directly impact educational practices in the distance program, it could have influenced students' ability to manage coursework in relation to other changes that occurred to their personal and professional responsibilities during this time.

While not necessarily a limitation, it is important to note that students conducted peer reviews only in DE2302, not subsequent courses in the first year. The previously cited 2020 study on peer feedback found a positive correlation between feedback frequency and satisfaction with implementation, though not necessarily with improved learning outcomes (Wu & Schunn, 2020, p. 11). Thus, satisfaction with peer review would improve with more opportunities and practice. Additionally, it might be valuable to explore the impact of peer reviews on the full papers instead of outlines alone.

Conclusion

This study describes the outcomes of formative assessments (both faculty and peer) on students of the USAWC. As expected, both faculty and students saw merit in the peer-review process. The process implementation also corresponded with a decrease in failure rates in the course that included peer reviews though there could be other explanations for that finding. The effect that peer reviews had on writing quality was less clear. The faculty will continue to look at ways to improve student outcomes without adding unnecessary burdens on the faculty and students.

Regardless of what future analyses find, USAWC students will be in leadership positions and will provide feedback to subordinates and peers through developmental assessments. This requires critical thinking skills. Peer-review practice in academic environments can enhance those skills.

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Appendix A

Description of Courses

DE2301–Strategic Leadership

The strategic leadership course introduces the students to foundational concepts and analytical frameworks they will use throughout the two-year program. There are two summative assessments for this course. The first is online discussion board participation, and the second is a set of three short essays (600 words each). Faculty members offered eligible students mentoring for all three essays but no peer feedback. The thought process was to have faculty demonstrate what valuable feedback looks like before starting peer feedback in the second course. The grades on this essay represent one variable.

DE2302–National Security Policy and Strategy

The national security policy and strategy course introduces new analytical frameworks (international relations theory and decision-making models). It covers the actors, institutions, and processes in the global and domestic environment and introduces students to the strategy formulation framework. There are also two summative assessments for this course. The first is an online discussion board simulating an interagency policy committee, and the second is a set of two short essays (750 words each). Students could participate in peer feedback using Peerceptiv for the second essay. Faculty members also provided eligible students mentoring for both essays. The grades on this essay represent another variable.

DE2303–War and Military Strategy

The war and military strategy course introduce students to classical theories of war and strategy. It has a case study on World War II and a block devoted to contemporary security challenges. As in the previous courses, there are two summative assessments for this course. The first is an online discussion board, and the second is a set of four short essays (ranging from three hundred words to 750 words). Students do not participate in a peer feedback assessment in this course. However, faculty members offer mentoring to eligible students for both essays. The statistical analysis below includes those paper grades.

DE2304–Global and Regional Issues

This is the last online course before students come to the first two-week resident course. In the first block of this course, students study new analytical frameworks and both conventional (e.g., major power) and nonconventional threats. Once again, there are summative assessments for this course. The first is a timed online exam consisting of three short essays (600 words each), and the second is an online discussion board developing a regional strategy. There is no peer feedback or mentoring provided. The statistical analysis includes the student grades on the exam.

Appendix B

Statistical Analysis

Table 1: The proportion of participants that who achieved excellent grades in DE2302 differed across years, X^2 (5, $\mathcal{N}$ = 2424) = 107.8, $p < .0001$. The number of high passes was greater than expected in AY23 (expected 112.6, actual 162) and AY24 (expected 120.1, actual 177).

Table 2: The authors also conducted Kendall Tau and Chi-square analyses to test the relationship between variables. There is a significant correlation between the DE2301 grade and the DE2302 grade (n = 401, τb = .12, p = .013) and between participating in Peerceptiv and participating in mentoring (X^2 [1] = 9.5, $p < .001$). There was not a statistically significant relationship between participating in Peerceptiv and grades in DE2302 (X^2 [2] = 1.4, p = .49) or between Peerceptiv and grades in DE2301 (X^2 [2] = 1.0, p = .59). Given the low correlation coefficients (less than .3), it was not surprising that the ordinal regression equation was not statistically significant.

Table 3: The proportion of participants who failed DE2303 differed across years, X^2 (5, $\mathcal{N}$ = 2358) = 17.9, p = .003. The number of failures was more than expected in AY23 (expected 50.9, actual 64) and in AY24 (expected 54.8, actual 68). The authors thought that writing might also improve in subsequent courses even without peer reviews. Again, the composition of the cohorts remains consistent across academic years.

Peer Reviewed

Analysis of Demographic and Experiential Interactions in Quantitative General Education

USAFA Courses and Their Impact on STEM Attrition

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Abstract

Science, technology, engineering, and mathematics (STEM) attrition occurs when undergraduates who are STEM-interested or initially declared STEM majors move away from these fields by switching majors or dropping out of college. This survey study examined this phenomenon at the U.S. Air Force Academy from the perspective of cadets who used to be STEM-interested or initially declared STEM majors and are graduating from non-STEM majors. The most impactful factors associated with STEM attrition were the accelerated pacing of instruction, the limitations in time and effort due to perceived excessive workload, and classroom experiences in Calculus I and II, General Chemistry I, and Mechanics Fundamentals. Cadets from certain demographic and socioeconomic groups reported experiencing significantly higher push factors away from STEM majors. The researchers discussed cadet recommendations to attract and retain STEM majors.

Higher education graduates with knowledge, skills, and abilities in STEM are essential for promoting innovation and economic growth as the United States faces many domestic and international challenges (Haslina & Karpudewan, 2019; Nadelson & Seifert, 2017), but universities are not graduating enough to meet current and future demands in federal, national defense, private, and nonprofit sectors (Iammartino et al., 2016; U.S. Government Accountability Office, 2018, 2022). The deficit of STEM professionals is especially a concern for the U.S. Department of Defense, including the U.S. Air Force and U.S. Space Force (DeLoatch et al., 2022; National Academies of Sciences, Engineering, and Medicine, 2015; National Research Council, 2010, 2012, 2014).

The availability of STEM graduates will depend on how many high school students decide to enroll in college to pursue these careers and how many complete a degree (Sithole et al., 2017; Xu, 2018). However, numerous academic and nonacademic factors influence enrollment and persistence, pushing students away from STEM careers (Funk & Parker, 2018; Malcom & Feder, 2016; Romash, 2019). STEM attrition is defined in terms of undergraduates who are STEM-interested or declared a STEM major but move away from these fields (Brewer et al., 2021; National Science Board, 2018; Seymour & Hunter, 2019; Singh et al., 2018). Leaving STEM is something that most students do not take lightly, as they need to weigh several extrinsic, intrinsic, and experiential factors (Chen, 2015; Chen & Soldner, 2013; Cohen & Kelly, 2020; Sjoquist & Winters, 2015; Wright, 2018). To better retain and graduate STEM-interested students, it is essential to consider how introductory STEM course structure is related to attrition.

Noncivilian postsecondary institutions also experience STEM attrition (Dwyer et al., 2020; O'Keefe et al., 2022, 2023). In the context of military academies, STEM-heavy academics provide the Armed Forces with the critical-thinking and quantitative-reasoning skills needed to fight increasingly technologically complex battles. However, questions remain about the perceived relative impact of academic and nonacademic factors leading to STEM departure.

Purpose and Research Questions

This study examined factors linked to STEM attrition from the perspective of U.S. Air Force Academy (USAFA) cadets in the humanities and social sciences divisions (HSSD) who were initially STEM-interested or in the basic sciences and engineering divisions (BSED). There were several research questions:

1. To what extent were HSSD cadets interested in STEM majors in high school or as undeclared first-year USAFA students?
2. To what extent did cadets from HSSD initially choose STEM majors in BSED?
3. How did cadets rate the influence of conceptual understanding, final grades, classroom experience, time and effort invested in STEM coursework, and

instructor pacing in core STEM classes in their decision to switch to non-STEM majors?

4. Is there an association between the reported influence of academic and nonacademic factors in a cadet's decision to switch to non-STEM majors and demographic or socioeconomic variables?
5. What recommendations did cadets propose to attract and retain STEM-interested cadets?

The findings of this study can help the USAFA and other undergraduate programs develop and implement academic and nonacademic interventions to increase interest in STEM, improve student success in these majors, and minimize STEM attrition.

Methodology

Participants

During the fall 2022 semester, the dedicated survey and assessment time, USAFA sent a request to participate, a consent form, and a survey link to a random sample of 500 HSSD upper-level students. Of these, 187 agreed to participate in the survey, and the researchers included them in some of the analyses below (i.e., the "full sample"). The target sample of interest was obtained by excluding 35 cadets who reported never being STEM-interested nor originally majoring in STEM and 16 who submitted significantly incomplete surveys, resulting in 136 cadets for other statistical tests.

Survey

The survey included three screening questions, asking whether the cadets had planned to major in STEM as high school students or undeclared cadets and wheth-

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er they declared a STEM major before switching to a non-STEM major. The following section asked cadets to rank 15 statements describing reasons that could have influenced their decision to declare a non-STEM major. The ranking used a Likert scale ranging from 1, representing factors that were not influential, to 10, for factors that were very influential in a cadet's decision to major in a non-STEM discipline. The statements referenced five STEM classes from the academy's core curriculum (Calculus I and II, Aeronautics Fundamentals, Mechanics Fundamentals, General Chemistry I, and Astronautics Fundamentals), subdivided into categories of classroom experience, understanding of the concepts covered in class, and final course grade. Additional ranking questions included broader factors of instructor pacing and invested time and effort.

The survey also asked cadets to recommend ways for USAFA to attract undecided cadets to declare a STEM major, allowing them to reflect on their own experiences and provide narratives to contextualize STEM attrition processes (Check & Schutt, 2012; Creswell, 2012). Finally, six demographic questions asked about a cadet's sex, race, ethnicity, preparatory school attendance (all of them, not just USAFA's), high school of origin, average annual family income, and whether participants were first-generation college students.

Analysis

The quantitative ranking data were categorical, and sample sizes were small in a few cases. As a result, the researchers reported Kruskal-Wallis statistics when comparing three or more groups and Mann-Whitney U test, which follows a Z distribution, for pairwise comparisons and post hoc analysis. Due to the exploratory nature of this study, the researchers used a significance level (p-value) of 0.05 or less to balance the risks of Type I and Type II errors. The open responses were manually

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analyzed using thematic analysis (Braun & Clarke, 2021; Creswell & Creswell, 2018). This process included (a) reading the cadet answers multiple times, (b) searching for preliminary themes based on frequently used words or phrases, (c) applying a tabular format to identify codes and their corresponding quotations, and (d) reviewing the themes and quotations, revising as needed. The researchers selected representative cadet responses to illustrate the themes (Boyatzis, 1998; Saldaña, 2021).

Results

Cadet STEM-Interest Before Declaring Non-STEM Majors (Full Sample, n *= 187)*

The survey revealed that 139 of 187 (74%) of the participants began their STEM interest in high school. Many cadets then considered engineering majors, with aeronautical, astronautical, and mechanical engineering as the top three choices. Cadets also considered chemistry, biology, and physics as career paths. Before declaring a college major, 135 of 187 (72%) cadets were still STEM-interested, with 60% considering an engineering major. Cadets still frequently considered majoring in aeronautical, astronautical, and mechanical engineering at this time, while computer science displaced physics as the third most popular major in the science and mathematics category. In both cases, many cadets frequently listed multiple STEM majors of interest.

Factors Associated with STEM Attrition (Target Sample, n *= 136)*

Although the ranking scale ranged from 1 to 10 (1 was not influential and 10 was very influential), the researchers grouped the ranking results into minor impact (mean rankings between 1 and 3), moderate impact (mean rankings between 4 and 7), and strong impact (mean rankings between 8 and 10). Table 1 shows the overall findings of this section.

Note the moderate and strong STEM attrition impacts of classroom experiences, mainly due to the Calculus I and II, General Chemistry I, and Mechanics courses. Final course grades, especially in Aeronautics and Astronautics Fundamentals, had the smallest impact on STEM attrition.

Classroom Experience. Almost two-thirds of cadets (65%) perceived that their classroom experience in Calculus I and II had a moderate or strong influence on their decision to move away from STEM majors. This percentage is much higher than those for Mechanics Fundamentals (53%) and General Chemistry I (51%). With 43% and 35%, the participants' classroom experiences in Aeronautics and Astronautics Fundamentals, respectively, were the least impactful when declaring a non-STEM major. Table 2 summarizes the classroom experience survey data.

Table 1
STEM Attrition Impact Heatmap Matrix

Core Class	Level	Classroom Experience Impact			Content Understanding Impact			Final Grade Impact		
		Minor	Moderate	Strong	Minor	Moderate	Strong	Minor	Moderate	Strong
Calculus I & II	Year 1	94	253	360	178	121	216	174	138	198
General Chemistry I	Year 1	130	182	333	190	143	126	188	132	153
Mechanics Fundamentals	Year 2	128	226	279	172	165	180	170	143	225
Aeronautics Fundamentals	Year 3	154	171	243	194	149	99	220	110	45
Astronautics Fundamentals	Year 4	172	198	135	200	143	63	202	154	36

Note. Values are weighted by an impact coefficient (2 for minor impact, 5.5 for moderate impact, and 9 for strong impact) and the sample size per cell.

Conceptual Understanding. About one in three cadets indicated that their mastery of content knowledge and skills in Mechanics Fundamentals (37%) and Calculus I and II (34%) was a moderate or strong push factor away from STEM and toward non-STEM majors. In contrast, 30%, 28%, and 25% of the cadets reported a moderate or strong influence on their content understanding in General Chemistry I, Aeronautics, and Astronautics Fundamentals, respectively. Table 3 summarizes the conceptual understanding data.

Final Class Grades. Like the previous content mastery factor, about one in three cadets perceived that their final grades in Mechanics Fundamentals (37%) and Calculus I and II (35%) had a moderate or strong influence on their decision to move away from STEM majors, followed by their grade in General Chemistry I (30%). The participants' final grades in Aeronautics and Astronautics Fundamentals were the least impactful when declaring a non-STEM major (24% and 19%, respectively). Table 4 summarizes the final grade survey data.

Time and Effort Management and Instructor Pacing. About 55% of the cadets indicated that time and effort commitments were a prominent push factor away from STEM, and 51% thought the pacing was also very influential. Table 5 summarizes the survey data for these two factors.

Statistical Analysis–Demographics (Target Sample, n *= 136)*

In this section, the researchers compared the median influence rankings in the previous 15 categories (three academic reasons multiplied by five core courses) with demographic and socioeconomic variables. The statistical analysis revealed that

Table 2

STEM Attrition Impact Rankings of Classroom Experience in Five Core Classes

Class	Mean +/- St Dev	Med	How much did your classroom experience influence the decision to ultimately declare a non-STEM major?									
			1	2	3	4	5	6	7	8	9	10
Calculus I & II	5.23 ± 3.11	6	30 22.6%	9 6.8%	8 6.0%	4 3.0%	14 10.5%	9 6.8%	19 14.3%	20 15.0%	9 6.8%	11 8.3%
General Chemistry I	4.50 ± 3.22	4	41 30.4%	11 8.1%	13 9.6%	6 4.4%	15 11.1%	5 3.7%	7 5.2%	18 13.3%	7 5.2%	12 8.9%
Mechanics Fundamentals	4.46 ± 3.16	4	40 29.4%	12 8.8%	12 8.8%	8 5.9%	12 8.8%	5 3.7%	5 3.7%	9 6.7%	3 2.2%	15 11.1%
Aeronautics Fundamentals	3.73 ± 3.29	2	66 48.9%	6 4.4%	5 3.7%	9 6.7%	12 8.9%	5 3.7%	5 3.7%	9 6.7%	3 2.2%	15 11.1%
Astronautics Fundamentals	2.91 ± 2.71	1	79 59.4%	5 3.8%	2 1.5%	4 3.0%	22 16.5%	6 4.5%	4 3.0%	3 2.3%	2 1.5%	6 4.5%

the average ranking of academic reasons that influenced cadets to move away from STEM majors was similar for all five courses regardless of cadet status as first-generation college graduates. The researchers found that cadets from families with \$65,000–\$100,000 annual incomes reported larger push factors due to their grade in Calculus I and II (4.10 mean impact ranking) and conceptual understanding of Aeronautics Fundamentals (3.29 mean impact ranking) compared with cadets from more affluent backgrounds (2.81 and 2.11 mean impact rankings, respectively; z = 2.15, p = 0.032 and z = 2.067, p = 0.039). Also, cadets who graduated from private schools or home-school reported a larger impact due to their classroom experience (6.04 mean impact ranking) and final grade (5.08 mean impact ranking) in Mechanics Fundamentals. Rankings for public school cadets were 4.20 and 3.45, respectively (z = 2.75, p = 0.006 and z = 2.72, p = 0.007). Cadets who attended preparatory schools and those from low socioeconomic backgrounds experienced the strongest push away from STEM due to academic factors. Tables 6 through 9 summarize these findings.

Recommendations to Minimize STEM Attrition

The last survey question asked cadets to provide recommendations for increasing the number of cadets graduating in STEM. Cadets used their experiences as context to provide actionable items for attracting undecided cadets to STEM majors and retain those who declared them. Twenty-four themes were identified, the top five of which are discussed below.

Table 3

STEM Attrition Impact Rankings of Conceptual Understanding in Five Core Classes

Class	Mean +/- St Dev	Med	How much did your level of understanding of the concepts taught in class influence the decision to ultimately declare a non-STEM major?									
			1	2	3	4	5	6	7	8	9	10
Mechanics Fundamentals	3.71 ± 2.92	3	45 33.1%	19 14.0%	22 16.2%	4 2.9%	8 5.9%	9 6.6%	9 6.6%	7 5.1%	4 2.9%	9 6.6%
Calculus I & II	3.56 ± 3.15	2	56 41.5%	22 16.3%	11 8.1%	4 3.0%	5 3.7%	5 3.7%	8 5.9%	8 5.9%	4 3.0%	12 8.9%
General Chemistry I	2.96 ± 2.73	1	70 51.9%	15 11.1%	10 7.4%	5 3.7%	10 7.4%	3 2.2%	8 5.9%	6 4.4%	3 2.2%	5 3.7%
Aeronautics Fundamentals	2.70 ± 2.49	1	76 56.3%	12 8.9%	9 6.7%	8 5.9	9 6.7%	3 2.2%	7 5.2%	7 5.2%	2 1.5%	2 1.5%
Astronautics Fundamentals	2.40 ± 2.33	1	87 65.4%	8 6.0%	5 3.8%	1 0.8%	18 13.5%	5 3.8%	2 1.5%	3 2.3%	1 0.8%	3 2.3%

Modify the Core Classes. The most frequent recommendation was to modify the core curriculum, the equivalent of general education classes at USAFA. Although many cadets did not provide specific suggestions to improve the core, others mentioned making these classes easier, slower-paced, manageable, and accessible. A few cadets suggested reducing the number of core classes or removing specific classes. One cadet noted that because of the substantial number of required core courses, classes in the major are out of reach until the fourth semester. An opposite recommendation was to add classes to the core, like a freshman-level engineering design process class. Other recommendations were to adjust the mix of STEM and non-STEM core classes based on the cadet's majors (less STEM core classes for non-STEM majors and vice versa) and to front-load core STEM classes to create an exposure bias toward STEM. "A cadet in their incoming year should be taking more STEM classes if only to put them in a STEM-oriented mindset for those majors," a cadet explained.

Advise First-Year Students About the Benefits and Perks of Majoring in STEM. Cadets recommended USAFA provide first-year students with additional information and better advice about the benefits of completing a STEM degree and specific major requirements, including the following:

- "[Providing] weekly email highlights for freshmen on the different majors."
- "[Planning and implementing] a summer engineering design program."
- "Bringing in graduates of those degrees to inform cadets."

Table 4

STEM Attrition Impact Rankings of Final Grade in Five Core Classes

Class	Mean +/- St Dev	Med	How much did your final class grade influence the decision to ultimately declare a non-STEM major?									
			1	2	3	4	5	6	7	8	9	10
Mechanics Fundamentals	3.74 ± 3.10	2.5	51 37.5%	17 12.5%	17 12.5%	4 2.9%	8 5.9%	10 7.4%	4 2.9%	9 6.6%	4 2.9%	12 8.8%
Calculus I & II	3.35 ± 3.08	1.5	67 50.0%	14 10.4%	6 4.5%	5 3.7%	9 6.7%	4 3.0%	7 5.2%	7 5.2%	8 6.0%	7 5.2%
General Chemistry I	3.01 ± 2.83	1	73 54.1%	10 7.4%	11 8.1%	5 3.7%	10 7.4%	4 3.0%	5 3.7%	7 5.2%	4 3.0%	6 4.4%
Astronautics Fundamentals	2.28 ± 2.18	1	90 67.7%	5 3.8%	6 4.5%	3 2.3%	18 13.5%	4 3.0%	3 2.3%	1 0.8%	0	3 2.3%
Aeronautics Fundamentals	2.14 ± 1.92	1	84 62.2%	16 11.9%	10 7.4%	3 2.2%	14 10.4%	2 1.5%	1 0.7%	4 3.0%	0	1 0.7%

- "Letting undeclared cadets spend time with the instructors and cadets in a classroom or laboratory."

Cadets also encouraged enhancing special events like Open House, Majors Night, or STEM Night oriented toward first-year cadets and providing recruitment incentives (including financial ones) for high-demand STEM majors.

Reduce Workload for STEM Majors. Cadets perceived majoring in STEM comes with an increased workload. Those who major in STEM "have no free time and seem like they are always struggling." One cadet mentioned that USAFA should be transparent about "how rigorous the academic course load is [because] some may not be able to handle it." Athletes and engineering cadets perceived the STEM workload as being particularly intense. A cadet proposed that these students should receive excusals from some military training requirements.

Two cadets mentioned that the U.S. Military Academy addressed workload issues by modifying the semester schedule, either by making it last longer but having a day off midweek to catch up on academics or by providing additional weekend time for academics. Other suggestions to reduce the workload included:

- "[Reducing the number of] core [classes], thus decreasing the pace."
- Decreasing the amount of homework since "cadets do not have the time to teach themselves the material outside of class and then only be able to ask questions in class."
- "[Modifying STEM classes to] go a little slower but explain the material in more depth."

Table 5

STEM Attrition Impact Rankings for Instructor Pacing and Workload Factors

Reason	Mean +/- St Dev	Med	How much did these reasons to do well in a STEM major influence your decision to ultimately declare a non-STEM major?									
			1	2	3	4	5	6	7	8	9	10
I would have needed instructors who could cover the material at a moderate pacing.	5.57 ± 3.45	6	32 23.7%	8 5.9%	9 6.7%	5 3.7%	7 5.2%	11 8.1%	12 8.9%	10 7.4%	18 13.3%	23 17.0%
I would have needed to spend more time and effort than I could afford.	5.44 ± 3.53	6	34 25.0%	8 5.9%	10 7.4%	8 5.9%	7 5.1%	9 6.6%	11 8.1%	8 5.9%	12 8.8%	29 21.3%

Interestingly, cadets noted that if reducing the workload of STEM cadets is not possible, they will be at a disadvantage for competitive opportunities tied to GPA and overall performance average, causing STEM attrition. Overall performance average determines graduation order of merit by weighing GPA at 50%, military performance average at 40%, and physical education average at 10%. Cadets provided two options to reduce GPA disparities:

- "[Rewarding] cadets better for selecting difficult majors, through grade balancing." This system sounds like those in high schools, where advanced placement and honors classes are weighted more than regular ones.
- "Making [non-STEM] majors more challenging. The Academy could evaluate whether the workload for a [STEM] major is significantly above that of fuzzy [non-STEM] majors."

Attract and Maintain High-Quality Instructors. Cadets perceived the content knowledge of STEM instruction as excellent. They did argue that some instructors could do a better job helping cadets understand the content knowledge and skills they are teaching, making it more likely for cadets to avoid STEM attrition. Other cadets thought instructors should be more considerate, understanding, approachable, and motivated. Instructors should be discerning in recognizing that some students may be struggling academically. On the other hand, instructors should not

Table 6

STEM Attrition Impact Rankings by Caucasian and Asian Minority Demographics

Academic Reason	Impact Ranking (mean ± St Dev)		Z	p
	Caucasian	Asian Minority		
Conceptual Understanding in Aeronautics Fundamentals	2.41 ± 2.36	4.22 ± 2.94	2.89	**0.004**
Conceptual Understanding in Mechanics Fundamentals	3.39 ± 2.84	5.09 ± 2.95	2.45	**0.014**
Final Grade in Mechanics Fundamentals	3.33 ± 2.92	5.00 ± 3.41	1.99	**0.046**

be intimidating, condescending, or make cadets "feel dumb" for asking questions. Cadets recommended providing additional professional development opportunities in pedagogy and teaching strategies.

Improve the Curriculum for Non-Core Classes. One cadet stated that some courses appeared designed to filter people out of STEM majors. Cadets differentiated between classes that were "well-structured" and did not add anything unnecessary, and those that appeared to go out of their way to make [the content] more difficult. Further recommendations included the following:

- "[Making] the learning environment more collaborative."
- "[Making] the focus of classes more on learning than difficulty."
- "[Making] them relevant to being warfighters and officers [by focusing] on the future fight."
- "[Avoid suggesting] summer STEM courses. Three weeks for any STEM course is too fast."

Other strategies to retain STEM majors included (a) expanding research and graduate school opportunities, (b) informing about STEM career opportunities in the Air Force and the civilian workforce, and (c) creating STEM minors.

Discussion and Recommendations

The transition to higher education is challenging, regardless of whether the universities are civilian or military (Conley et al., 2014; González-Espada & Napoleoni-Milán, 2006). Add a strict adherence to a four-year STEM program, military, leadership, and physical education tasks, and it is not difficult to understand the multiple push factors away from STEM experienced by participants.

Cadet responses may reveal that, although the curriculum designed and prepared by USAFA is adequate to meet their needs, they perceive implicit messages that not all cadets work hard enough, are intelligent enough, or can multitask effectively enough to enter the culture of science or engineering. The perception that

Table 7
STEM Attrition Impact Rankings by Caucasian and Asian Minority Demographics

Academic Reason	Impact Ranking (mean ± St Dev)		Z	p
	Caucasian	Asian Minority		
Final Grade in Mechanics Fundamentals	3.33 ± 2.92	4.77 ± 3.19	2.35	**0.019**
Final Grade in Calculus I & II	3.09 ± 3.04	4.83 ± 3.35	2.02	**0.043**
Conceptual Understanding in Aeronautics Fundamentals	2.17 ± 2.11	3.07 ± 1.89	2.31	**0.021**
Final Grade in Astronautics Fundamentals	2.11 ± 2.06	3.46 ± 2.15	2.82	**0.005**

non-STEM programs result in higher GPAs also leads some cadets to leave STEM programs. Although many of the cadets' recommendations to attract and retain their peers in STEM majors echo those identified in civilian universities (Seymour & Hewitt, 1997; Seymour & Hunter, 2019), there are a few actionable items that USAFA could implement without significantly affecting the formal curriculum's rigor.

Revising the Calculus Sequence

One of the more salient findings of the study was the cadets' perceived impact of the classroom experience in Calculus I and II in their decision to depart STEM majors. Their recommendation to revamp the calculus sequence is consistent with recent studies at USAFA related to STEM attrition (Dwyer et al., 2020; O'Keefe et al., 2022) and similar studies that identify these courses as leading cause of STEM attrition (Ellis et al., 2014; Núñez-Peña et al., 2013; Seymour & Hewitt, 1997).

The Mathematical Sciences Department at USAFA recently started to modernize its core calculus courses to emphasize modeling and pattern visualization with actual data, using current technology for computations unrealistic by hand, and promoting student exploration and experimentation (Saxe & Braddy, 2015; Schumacher et al., 2015). Early evidence suggests promising results (Horton, 2023; Johnson et al., 2024).

Provide Enhanced Academic Support to Cadets from At-Risk Demographic Groups

The socioeconomic status of families is associated with children's achievement in school and degree attainment, causing low-income and first-generation college students to become less likely to finish STEM degrees (Estrada et al., 2016; Ferrare & Lee, 2014; Jackson, 2018; Knight, 2017; President's Council of Advisors on Science and Technology, 2012). Uncovering that classroom experiences, conceptual understanding, and final grades in core classes are disproportionally impacting some so-

Table 8
STEM Attrition Impact Rankings by Preparatory School Attendance Demographics

Academic Reason	Impact Ranking (mean ± St Dev)		Z	p
	Direct Enrollment	Prep School		
Conceptual Understanding in Mechanics Fundamentals	3.21 ± 2.66	5.38 ± 3.16	3.59	**0.001**
Conceptual Understanding in Calculus I & II	3.20 ± 2.97	4.90 ± 3.46	2.75	**0.006**
Final Grade in Calculus I & II	2.99 ± 2.93	4.56 ± 3.31	2.43	**0.015**
Conceptual Understanding in Aeronautics Fundamentals	2.32 ± 2.17	3.94 ± 2.99	3.01	**0.003**
Conceptual Understanding in Astronautics Fundamentals	2.10 ± 2.06	3.32 ± 2.90	2.27	**0.023**

cioeconomic and demographic groups should motivate USAFA to design and plan a more detailed tracking of STEM attrition.

Preparatory school graduates deserve a separate mention. These programs remediate academic deficiencies so that their course performance at USAFA will be like nonpreparatory school graduates. The findings suggest that preparatory school graduates are experiencing disproportionate push factors away from STEM, confirming the conclusion of a recent study (O'Keefe et al., 2022). The Air Force should critically examine the preparatory schools' STEM curriculum to better align it with best practices in STEM education (Hallström & Schönborn, 2019).

Reducing Workload for STEM Majors

An option suggested by cadets was to follow a midweek study day without scheduled classes, reportedly in place at the U.S. Military Academy (USMA) at West Point. Communication confirmed that a version of this scheduling system was in place but will soon be cancelled by USMA. At USAFA, a weekly "Wednesday off" model would lengthen the semester, negatively impacting many other activities on campus, especially those scheduled for the summer.

A second alternative to address the perceived excessive workload would be to statistically weigh USAFA STEM coursework to compensate for the additional difficulty. A model like this does not exist at the college level, only in high schools with advanced placement and honors classes. If USAFA considers STEM course weighing, additional research like Tomkin and West (2022) is needed to (a) confirm that graduation GPAs per USAFA division are significantly disparate and (b) identify weights that could produce statistically similar graduation GPAs for all divisions.

Although cadets suggested avoiding summer STEM courses, a recommendation to reduce workload would be for USAFA to revise the current summer course lottery

Table 9

STEM Attrition Impact Rankings by Average Annual Cadet Family Income

Academic Reason	Impact Ranking (mean ± St Dev)		Z	p
	> $100,000	< $65,000		
Classroom Experience in Calculus I & II	5.06 ± 3.14	6.63 ± 2.50	1.98	**0.048**
Conceptual Understanding in Mechanics Fundamentals	3.32 ± 2.87	4.30 ± 2.52	2.28	**0.022**
Final Grade in Mechanics Fundamentals	3.11 ± 2.94	4.90 ± 2.85	3.09	**0.002**
Classroom Experience in Astronautics Fundamentals	2.85 ± 2.78	4.30 ± 2.77	2.30	**0.022**
Conceptual Understanding in Aeronautics Fundamentals	2.11 ± 1.95	3.30 ± 2.62	2.35	**0.019**
Conceptual Understanding in Astronautics Fundamentals	1.97 ± 1.82	3.00 ± 2.20	2.51	**0.012**
Final Grade in Aeronautics Fundamentals	1.85 ± 1.68	2.55 ± 2.01	1.96	**0.050**
Final Grade in Astronautics Fundamentals	1.80 ± 1.61	3.00 ± 2.08	2.93	**0.003**

system and expand the offerings of non-STEM courses. This alternative would free up time for STEM cadets during their regular semester. The impact on the many military, survival, airmanship, and leadership requirements cadets complete during the summer is unknown.

Keeping Interest for STEM

Cadets were savvy in pointing out that STEM-interested cadets must have multiple sources of quality information to make a well-informed decision about the benefits of completing a STEM degree and specific major requirements. In addition to providing additional opportunities for STEM majors to engage in research and STEM-related outreach, USAFA should promote frequent, informal peer-to-peer interactions (Drane et al., 2014; Micari et al., 2010). These can be events like Open Houses, Majors Night, or STEM Showcases with first-year cadets, graduating seniors in STEM, and graduating seniors in non-STEM majors who experienced push factors away from STEM.

USAFA should avoid the opposite of peer learning, which is peer misinformation. One researcher shared his experience with basic cadet training cadre alerting first-year cadets to avoid Calculus III, "poisoning the well" of undecided STEM-interested cadets and adding stress to those who already decided to major in STEM. USAFA should expose cadets to various perspectives on academic majors during basic training, which should minimize peer misinformation.

Another way to keep cadets interested in STEM is to challenge the misconception that Air Force officers rarely use their undergraduate STEM degrees in their duties.

USAFA should continually inform cadets about the importance of STEM majors for the expected technological sophistication of future conflicts, especially cyber sciences, space systems, complex systems, and research and development (Rempfer, 2019).

One cadet recommendation to retain interest in STEM was to develop a first-year engineering foundations class. Research supports introduction to engineering courses in the first year of college (Patangia, 2003; Sable et al., 2014; Watson et al., 2015). The Department of Civil and Environmental Engineering, the Department of Management, and the Office of Diversity and Inclusion piloted an introduction to engineering design courses in the fall 2023 semester, and they are evaluating its effectiveness.

Conclusion

This study examined academic and nonacademic factors linked to cadets switching out of STEM majors. The researchers concluded that about three-fourths of the participants reported interest in STEM (high school and during their first year), and about two-thirds of them even initially declared STEM majors. The accelerated pacing of instruction, the limitations of time and effort due to the workload, and the classroom experience in Calculus I and II were the most impactful factors related to STEM attrition. Two factors, instructor pacing and excessive workload, also emerged in the analysis. The researchers identified moderate impacts in classroom experiences in General Chemistry I, classroom experiences in Mechanics Fundamentals, conceptual understanding and final grade in Mechanics Fundamentals, conceptual understanding and final grade in Calculus I and II, and final grade in General Chemistry I.

The researchers also found that cadets from lower-income families, who attended preparatory schools, who are racial or ethnic minorities, and who attended private schools or were home-schooled experienced stronger push factors toward STEM attrition. Cadets provided numerous ideas to prevent STEM attrition; however, some are more feasible than others in the context of the legal and curricular realities of USAFA.

Despite various study limitations like cadet self-selection for completing the survey, low overall survey response rates, not including other introductory core classes like Physics I and Biology I, and the lack of data associated with the revamped Calculus I and II sequence, the findings significantly expand previous studies at USAFA (Dwyer et al., 2020; O'Keefe et al., 2022, 2023) that point to STEM attrition as an ongoing, concerning challenge for the U.S. Department of Defense.

Although this study was completed in the context of USAFA, the problem of STEM retention and attrition is broad enough that this study's findings can inform similar ones in other contexts such as military postsecondary institutions other than USAFA and civilian colleges and universities, both public and private. Some factors are common to these groups. For instance, the accelerated pacing of instruction in introductory STEM courses has been widely reported by both cadets and civilian students; opportunities to apply research methods to revamp these courses in light of new technologies and instructional approaches should be a priority. The limitations in time and effort due to perceived excessive workload are a similar consequence for cadets and students, although the causes may be different for both groups (e.g., physical education and military leadership duties for cadets; part-time jobs and family responsibilities for civilians). The role of persistence or grit as a personality trait that differentiates cadets or civilian students who finish STEM degrees from those who leave is an additional factor worth researching. In fact, a future research study that examines persistence among USAFA's graduating cadets in STEM is in the data collection stage.

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Large Animal Training for U.S. Army Veterinary Services Soldiers in Europe

An Experiential and Collaborative Approach

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Abstract

U.S. Army veterinary services delivers public health services for companion animals and livestock yet continuously needs to train soldiers to optimize skills and veterinary readiness. We designed an experiential and collaborative large animal (sheep, cattle, horse) training program in the United Kingdom for Public Health Activity–Italy soldiers (from England, Germany, Italy, Spain, and Türkiye). This training targeted specific tasks and incorporated environmental influences, animal handling, and livestock disorders and assessments. Eight veterinarians (64F/A) and 24 animal care specialists (technicians) (68T) participated and completed pre-/postevaluations. An independent sample t test with a nonparametric Mann-Whitney U test was used to determine if changes in knowledge, skills, and abilities occurred. For livestock behavior and handling questions, technicians always reported significant positive changes and veterinarians for 50% of questions. For examination and treatment questions, technicians always reported significant positive changes and veterinarians for 80% of questions. For environment, nutrition, and body condition questions, technicians always reported significant positive changes and veterinarians for 75% of questions. For internal and external parasite questions,

technicians and veterinarians always reported significant positive changes. The magnitude of change was always two times greater for technicians. Fourteen participants stated that hands-on portions were most useful (61%). Future training needs to include blood collection and analysis, injections, trimming hooves, zoonotic diseases, necropsy, and feed and slaughter inspection.

The U.S. Army Veterinary Corps was officially established as a part of the Army Medical Department with the passage of the National Defense Act of 1916. However, the need for the treatment of animals in military service was recognized by Gen. George Washington in the Continental Army (1775–1783). At the beginning of World War I, there were only 72 veterinary officers in the Army and no enlisted soldiers. The Overman Act of 1917 allowed for the expansion of veterinary personnel, including enlisted soldiers, and it peaked at 2,234 veterinarians and 18,007 soldiers (Coates & Caldwell, 1961). These veterinarians and soldiers cared for over 481,000 horses and mules, inspected 1.26 billion pounds of meat and dairy products, and condemned 11 million pounds. During World War II, veterinarian strength peaked at over 2,100 and between 6,000 to 8,000 soldiers, who cared for 56,000 horses and mules and inspected over 142 billion pounds of meat and dairy products. This is a significant change in scope due to the shift to mechanized warfare but also to the volume of soldiers. In the China-Burma-India theater, veterinarians inspected whole herds of animals as U.S. forces had to live off the land. Due to rinderpest, foot-and-mouth disease, and anthrax, numerous animals were rejected (Derstin, 1991). Today, Army Veterinary Services is composed of approximately 2,580 soldiers (700 veterinary corps officers, 80 food safety warrant officers, 1,800 68T animal care specialists, and 68R veterinary food inspection specialists), fewer than 400 horses, and the auditing responsibilities at more than 1,600 facilities around the world.

Throughout its history, the mission of Army Veterinary Services has largely remained the same. Special Regulations No. 70, 15 December 1917, *Special Regulations Governing the Army Veterinary Service*, defined two focus areas. The first was "to protect the health and preserve the efficiency of the animals of the Army"; and the second was to "also provide for the inspection of meat-producing animals before and after slaughter and of dressed carcasses; and for the inspection of dairy herds supplying milk to the Army." (AMEDD Center of History & Heritage, 2024). Beginning with the 1922 version of Army Regulation 40-2005 and remaining through the end of World War II, the mission further clarified duties in both peace and war and the provision of food for soldiers, as stated, "is charged in peace and war with duties falling under two definite heads: First, those in connection with the animals of the Army; second, those connected with the food supplies of troops that are of animal origin" (Coates & Caldwell, 1961, p. 17). Today, the Army is the Department of Defense's executive agent for providing veterinary public and animal health services.

As such, veterinary services are charged "to plan and deliver food protection, animal health and welfare, veterinary public health, training, research, development, testing, and evaluation across a range of military operations" (Department of Defense, 2013, pp. 1–2).

Clearly the modern mission of the U.S. Army Veterinary Services has evolved as military technology has moved from animal-based combat (i.e., the reliance on horses for transport and attack) to machines and computers (Bielakowski, 2000; Hendrix, 1993). Further, the rules of engagement have changed, international conflicts have varied, and global supply chain and connectedness have grown. The growth of international commerce and transmission also requires that an enhanced inspection and surveillance program is in place to reduce or avoid the transmission of problematic insects and disease pathogens (Burke et al., 2012; Calkins & Scasta, 2020; Dudley, 2004). Tasks have therefore required that U.S. Army veterinarians and animal care specialists, henceforth "technicians," have an enhanced understanding of the social and environmental context of animals. This enhanced understanding ensures that they can continue to provide critical animal care and also surveille, inspect, and communicate about diverse and ever-changing food animal needs in addition to providing support to military working dogs. This complex modern mission requires innovative and interdisciplinary training that is learning-centric (Williams, 2020). Ideally, such training would employ diverse teaching methods including delivery of technical details via lecture, teaching from multiple subject-matter experts (Diezmann & Watters, 2015), experiential learning (Barron et al., 2017), critical thinking with a framework for future duties (Parenteau, 2021), and problem-solving (Dale et al., 2008).

Given the modern evolution of the U.S. Army Veterinary Services' mission and training needs, we designed targeted hands-on learning opportunities in the European context through a collaboration among the U.S. Army Veterinary Services' Public Health Activity–Italy, University of Wyoming (UW), Scotland's Rural College (SRUC), and the British Army's Household Cavalry. This integrated training curriculum targeted specific tasks and was designed to understand the environment in which these animals exist, the influence of the environment on animal health, how to handle animals, and how to conduct specific tasks and techniques. Implications of this project will inform future training for U.S. Army Veterinary Services to develop a modern and globally ready force with contextually relevant competencies (Brou et al., 2022).

Materials and Methods

Specifically, we designed an experiential training opportunity focused on sheep, cattle, and horses. The idea for the training emerged after Calkins completed a long-term health education and training program at UW that included research on livestock pathogens, parasites, and toxic plants. In these research endeavors (and under

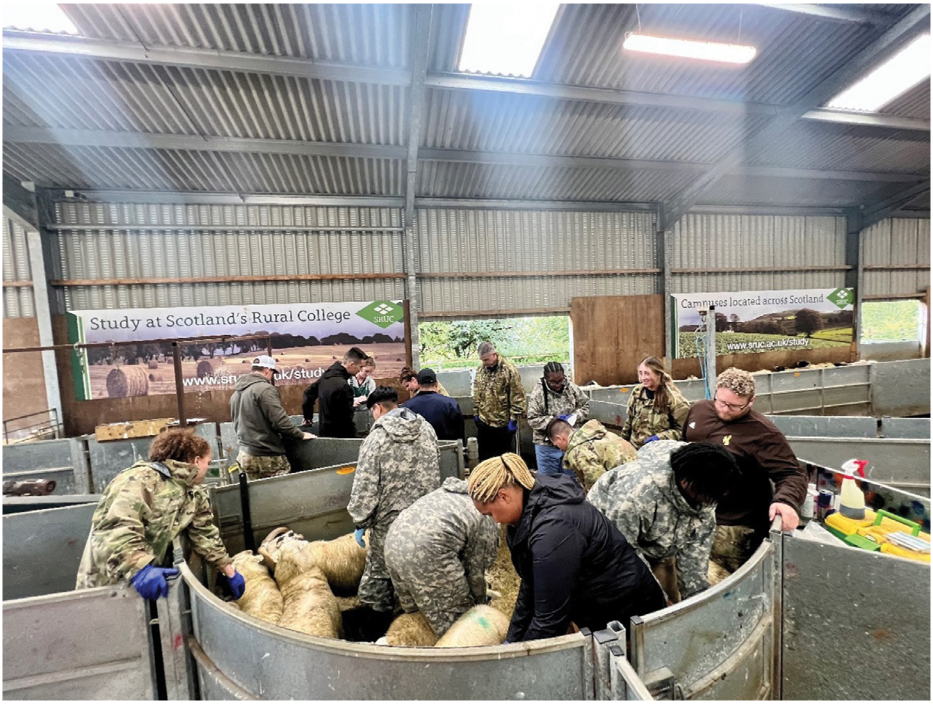
UW Institutional Animal Care and Use Committee approval as appropriate), Calkins analyzed disease data from public databases. Additionally, he analyzed collected cattle weights, blood from the coccygeal vein for hematology profiles, vital rates, ultrasounds, and invited a veterinary detachment from Fort Carson, Colorado, to assist, where they received hands-on training (Calkins, 2020; Calkins & Scasta, 2020; Calkins et al., 2021). In addition, Calkins assisted other UW graduate students with sheep research in which the team measured growth performance and body weight changes, rectal fecal collection, and blood collection from the jugular vein. These Long-Term Health Education and Training (LTHET) opportunities facilitated the development of this training idea for active-duty U.S. Army veterinarians and technicians.

Collaboration among the Public Health Activity–Italy, UW, SRUC, and the Household Cavalry Regiment was initiated to design targeted hands-on learning opportunities in the European context (i.e., the specific regulatory context for disease, medicine, approval, and reporting that is unique to Europe and the European Union). Training curriculum targeted specific tasks and was designed to understand the environment in which these animals exist, the influence of the environment on animal health, how to handle animals, and how to conduct specific tasks and techniques listed in the 68T individual critical task list (ICTL). ICTLs are skills identified by the Army for the maintenance of combat readiness in each military occupational specialty. Skill level 10 68Ts (E–E4) are responsible for mastering 105 ICTLs, of which 13 (12.38%) of the tasks are specific to large animals. Tasks range from performing physical restraint, physical examinations, administering oral and intravenous medications, to providing hoof care, taking radiographs, and providing first aid for equine colic (potentially a life-threatening gastrointestinal problem). Understanding the environment is important for an enhanced understanding of problems with animal productivity, disease and parasite exposure, physical capabilities, immunity, and reproduction potential. This will assist soldiers with not only treating symptoms but also causes of disorders.

A total of eight veterinarians and 24 technicians participated fully in the training and completed pre- and postevaluations. Other attendees included three veterinarians and technicians that assisted in setting up the training as well as two higher ranking Army officials. We used a combination of teaching strategies to meet various student learning preferences (Driver, 2021), including lecturing, live animal demonstrations, experiential opportunities to handle livestock, team tasks that required the use of specific techniques, and two retrospective problem sets (see Figure 1). This combination of teaching strategies correlates with cognitive learning theory proposed by Bloom (1956) and the increasing complexity of learning that scaled from knowledge (addressed by introductory lectures) to application (addressed by hands-on tasks), and ultimately to synthesis (addressed by retrospective problem sets). All animal handling for educational and training purposes was approved by the SRUC-Animal Experiments Committee on 15 August 2023 (Protocol

Figure 1

29 August 2023, Scotland's Rural College Hill and Mountain Research Centre-Crianlarich, Scotland



Note. Soldiers from Public Health Activities–Italy and Rhineland Pfalz, and the 64th Medical Detachment (Veterinary Service Support) along with professors from the University of Wyoming perform comprehensive physical examinations and FAMACHA© scoring to assess internal parasitism levels. Sheep are sorted into smaller groups to allow for ease of handling and to reduce animal stress. (Photo by Maj. Craig Calkins, U.S. Army)

Identification: BOR 2023-018 MIX A00). To measure the efficacy of the training, we administered a participant evaluation at the beginning of the training ("pre") and at the conclusion of the training ("post") (approved by the UW-Institutional Review Board as exempt for human subjects research on 18 August 2023). The evaluation included 22 questions assessing either knowledge or ability/application with a five-point Likert scale (1 = "Strongly Agree," 2 = "Agree," 3 = "Neutral," 4 = "Disagree," 5 = "Strongly Disagree"). In addition, three open-ended questions were asked about what was the most useful, how could the training be improved, and what additional topics should be covered.

Day 1. The training started at the SRUC Hill and Mountain Research Centre near Crianlarich, Scotland. After introductions, a safety briefing was provided as well as an overview to provide clarity of purpose. At this point, we administered the baseline or preevaluation. A sheep gathering demonstration was then provided by SRUC staff that used two trained working dogs and three personnel to bring the flock into the barn with an ad hoc discussion about animal movement and how to optimally position oneself. We then moved to the pasture sites (improved pasture, cultivated pasture, and rangeland) representative of forage resources used in grazing systems where presentations regarding types of plants, forage production, poisonous plants, and grazing animal nutrition were delivered by SRUC and UW staff. Participants were able to examine pastures, identify plants, and interact with subject-matter experts from SRUC and UW individually or in small groups. We then moved into the sheep barn and handling facilities and discussed principles of animal handling facility design and animal movement (by hand, with traditional panels and gates, and with a belt conveyor system) and concepts of flight zones and points of balance, which was followed by a presentation about sheep body condition scoring by UW staff. Additional emphasis was placed on designing temporary handling facilities to simulate in-field conditions where resources may be limited. We then split participants into three smaller groups to allow for hands-on learning including (1) group-pen handling and restraint basics, (2) processing sheep through a typical alley/raceway for body condition scoring (Thompson & Meyer, 1994), and (3) to work sheep through the conveyor system and examine sheep generally including feet. We concluded the day with a hypothetical scenario problem set about animal handling facility design and environmental considerations on nutrition and animal well-being. Soldiers had to consider the task of procuring 400 lambs from a north African country in an extensive pasture with limited forage. Specifically, soldiers had to describe (1) how they would gather the sheep, process the sheep, and separate lambs from ewes; (2) how they would assess the body condition of sheep; (3) and anticipate any additional logistical considerations of procurement.

Day 2. We returned to the SRUC–HMRC and started the morning with presentations by Dr. Paul Wood, an SRUC veterinarian, about how to conduct routine physical exams, vital rates, oral and injection administration of medicines, sedation and anesthesia, and hoof care. Wood then provided more hands-on demonstrations of handling sheep and sheep restraint techniques to conduct physical exams and locate the jugular vein. We then split participants into three groups where they were each assigned around 10 ewes each and challenged to conduct routine exams of each animal including identification, general assessments, body condition score, hoof, udders, vital rates (pulse and respiration), and fecal soiling, which can be an indication of internal parasite infestation. We then received presentations about ectoparasites and endoparasites by Army, SRUC, and UW staff followed by presentations about methods for assessing fecal samples and applying the FAMACHA assessment of ocular mucous membrane color as an indicator of anemia and internal parasite infestation (Van Wyk et al., 2002). We then split participants into two groups to allow for the opportunity to (1) conduct microscope assessments of fecal slides for endoparasites and (2) assess lamb identification, FAMACHA score, and fecal soiling (mean of 28 lambs per group) (see Figure 1). We concluded the day with a hypothetical scenario problem set about parasites. Soldiers had to consider the task of procuring 2,000 lambs from a European country characterized by a wet climate with high potential for internal parasite infestations, and they had to oversee the subsequent feeding program prior to slaughter. Specifically, soldiers had to consider internal parasite infestations and treatment for (1) how they would assess individual animals and what internal parasites would be of potential concern, (2) how slaughter would be delayed relative to administration of an anthelmintic, and (3) feed and housing program.

Day 3. We traveled to the SRUC Barony and SRUC Crichton farms near Dumfries where we focused on cattle. After receiving presentations from the SRUC staff, we then split participants into five groups where they had the opportunity to (1) gather a group of 15 heifers in a pasture and move them through a gate and down a lane; (2) sort, weigh, administer bolus and an oral drench to heifers; (3) observe cattle hoof trimming; (4) observe calf rearing and discuss calf health including pneumonia and an ultrasound of lungs; and (5) halter a cow and conduct routine assessments of pulse, respiration, rumen motility, with a discussion of blood collection from the coccygeal vein. After lunch, soldiers moved to the dairy for videos about cattle handling, milking system overview, nutrition and rations, and ultimately to milking cows.

Day 4. This was a travel day from Glasgow, Scotland, to London, England.

Day 5. We traveled to the Household Cavalry stables in London where we focused on horses. We received an orientation from a major (Royal Army Veterinary Corps) in the unit and then spent time as the rotating guard prepared in the yard for inspection. This allowed for the opportunity to talk to the mounted unit commander. We then proceeded to break into three groups to go through (1) the stables with a veterinary technician, (2) the farrier shop with farriers, and (3) the saddlery and equipment stockroom. Presentations included general comments about nutrition, feet handling, and tack. We then proceeded to the Household Cavalry Museum for presentations about the military history of the unit. At the end of these presentations, participants completed the postevaluation.

To determine if changes in knowledge, skills, and abilities were significant, we used an independent sample t test with a nonparametric Mann-Whitney U test for the Likert-scale data from the pre- and postevaluation with a p value of < 0.05 considered statistically significant (de Winter & Dodou, 2010). In these analyses, for each of the 22 Likert-scale questions we used the alternative hypothesis that preevaluation responses ≠ postevaluation responses stratified separately for each job type (veterinarian or technician). For the veterinarian group, three questions had variance equal to zero in the postevaluation responses, which did not allow for models to run; in these instances, we plotted bar graphs with standard errors and if the mean of the postevaluation response did not fall within the range of the standard error of the preevaluation response, then we considered those changes significant. All analyses were conducted in JASP open-source software (JASP Team, 2023). For the three open-ended questions, we summarized responses into major themes and particularly unique or useful responses.

Results

The preevaluation was administered on Monday, 28 August 2023 (day 1) with 16 technicians and eight veterinarians completing the instrument. The postevaluation was administered on Friday, 1 September 2023 (day 5) with 15 technicians and eight veterinarians completing the instrument. Attendees came from cross the European theater, including Germany, Italy, Spain, England, and Türkiye. Veterinary corps officers included one lieutenant colonel 64F (veterinary clinical medicine officer), and seven captain 64As (field veterinary service officer). Animal care specialists (68T) varied in rank, including two staff sergeants, 11 sergeants, and three specialists. At the time of training, the average age of captains was 30 years and eight months, with two years and one month average time as a veterinarian and an average of three years' time in service. Technician average age at the time of training was 28 years and four months, with six years and 11 months average time as a 68T and an average of seven years and four months' time in service.

For the four questions about livestock behavior, handling, and restraint, technicians always reported significant and positive changes and veterinarians reported significant and positive changes for two of the four questions (see Table 1). For understanding of how to perform restraint of sheep, technicians changed from "Disagree" to "Strongly Agree" ($p < 0.001$) and veterinarians changed from "Agree" to "Strongly Agree" ($p = 0.027$). For understanding of how to perform restraint of cattle, technicians changed from "Disagree" to "Agree" ($p < 0.001$) and veterinarians did not significantly change ($p = 0.112$; reporting "Agree" in the preevaluation). For understanding of how to perform restraint of horses, technicians changed from "Disagree" to "Agree" ($p = 0.010$) and veterinarians did not significantly change ($p = 0.444$; reporting "Agree" in the preevaluation). For understanding animal flight zones, blind spots, and optimal handler position to initiate movement, technicians changed from "Neutral" to "Strongly Agree" ($p < 0.001$) and veterinarians did not significantly change ($p = 0.096$; reporting "Agree" in the preevaluation) (Table 1).

For the five questions about examination and treatment of livestock, technicians always reported significant and positive changes and veterinarians reported significant and positive changes for four of the five questions (see Table 2). For ability to perform physical examination of livestock, technicians changed from "Disagree" to "Agree" ($p < 0.001$) and veterinarians changed from "Agree" to "Strongly Agree" ($p = 0.043$). For understanding how to administer oral medication to livestock,

Table 1
Livestock Behavior, Handling, and Restraint

	Technicians (68T)			Veterinarians (64F/64A)		
Question	**Pre**	**Post**	**Pre → Post Change**	**Pre**	**Post**	**Pre→ Post Change**
I understand how to perform restraint of ***sheep***?	4.4	1.4	Disagree → S. Agree	2.4	1.3	Agree → S. Agree
I understand how to perform restraint of ***cattle***?	4.4	1.9	Disagree → Agree	2.0	1.3	Agree; NS
I understand how to perform restraint of ***horses***?	3.6	2.4	Disagree → Agree	1.6	1.6	Agree; NS
I understand animal flight zones, blind spots, and where to position myself to initiate animal movement?	3.2	1.5	Neutral → S. Agree	2.1	1.1	Agree; NS
Mean	3.9	1.8	Magnitude = 2.1	2.0	1.3	Magnitude = 0.7

Note. Pre → Post changes noted are significant at $p < 0.05$ and nonsignificant = NS.

technicians changed from “Disagree” to “Strongly Agree” ($p < 0.001$) and veterinarians changed from “Agree” to “Strongly Agree” (note models for veterinarians would not converge due to zero variance in the postevaluation group; changes are considered significant based on no overlap of standard errors). For capability of routine hoof care of livestock, technicians changed from “Disagree” to “Neutral” ($p < 0.001$) and veterinarians did not significantly change ($p = 0.501$). For ability to assess fecal material from livestock and identify potential animal health problems, technicians changed from “Disagree” to “Agree” ($p < 0.001$) and veterinarians changed from “Neutral” to “Agree” ($p = 0.007$). For understanding injection site selection, types of injections, and withdrawal time concepts, technicians changed from “Disagree” to “Agree” ($p < 0.001$) and veterinarians changed from “Agree” to “Strongly Agree” ($p = 0.016$).

For the eight questions about the environment, nutrition, and body condition of livestock, technicians always reported significant and positive changes and veterinarians reported significant and positive changes for six of the eight questions (see Table 3). For ability to systematically assess sheep body condition, technicians changed from “Strongly Disagree” to “Agree” ($p < 0.001$) and veterinarians changed from “Neutral” to “Strongly Agree” (note models for veterinarians would not converge due to zero variance in the postevaluation group; changes are considered significant based on no overlap of standard errors). For ability to systematically assess beef cattle body condition, technicians changed from “Strongly Disagree” to “Agree” ($p < 0.001$) and veterinarians changed from “Neutral” to “Strongly Agree” ($p = 0.009$). For ability to systematically assess dairy cattle body condition, technicians changed from “Strongly Disagree” to “Agree” ($p < 0.001$) and veterinarians changed from “Neutral”

Table 2
Examination and Treatment of Livestock

	Technicians (68T)			Veterinarians (64F/64A)		
Question	**Pre**	**Post**	**Pre → Post Change**	**Pre**	**Post**	**Pre→ Post Change**
I can perform physical examination of livestock?	4.1	2.0	Disagree → Agree	2.3	1.3	Agree → S. Agree
I understand how to administer oral medication to livestock?	3.5	1.3	Disagree → S. Agree	1.8	1.0	Agree → S. Agree[1]
I am capable of routine hoof care of livestock?	4.1	2.5	Disagree → Neutral	2.6	2.0	Neutral/Agree; NS
I am able to assess fecal material from livestock and identify potential animal health problems?	4.4	1.6	Disagree → Agree	3.3	1.6	Neutral → Agree
I understand injection site selection, the type of injections, and withdrawal time concepts?	4.3	2.0	Disagree → Agree	2.0	1.1	Agree → S. Agree
Mean	4.1	1.9	Magnitude = 2.2	2.4	1.4	Magnitude = 1.0

Note. Pre → Post changes noted are significant at $p < 0.05$ and nonsignificant = NS.
[1] Indicates models that cannot converge due to 0 variance in the postevaluation group where all participants indicate "strongly agree" and changes are considered significant based on no overlap of standard errors.

to "Strongly Agree" ($p = 0.017$). For ability to systematically assess horse body condition, technicians changed from "Disagree" to "Neutral" ($p = 0.010$) and veterinarians did not significantly change ($p = 0.273$; generally reporting "Agreed"). For understanding the reproductive and animal health implications of poor body condition in livestock, technicians changed from "Disagree" to "Agree" ($p < 0.001$) and veterinarians changed from "Agree" to "Strongly Agree" ($p = 0.016$). For understanding the forage characteristics that can influence body condition of livestock, technicians changed from "Disagree" to "Agree" ($p < 0.001$) and veterinarians changed from "Neutral" to "Agree" ($p = 0.026$). For ability to rapidly assess the nutritional quality of rangeland and pasture, technicians changed from "Disagree" to "Agree" ($p < 0.001$) and veterinarians did not significantly change ($p = 0.220$; generally reporting "Neutral"). For understanding minimum nutrient requirements of livestock, technicians changed from "Strongly Disagree" to "Agree" ($p < 0.001$) and veterinarians changed from "Neutral" to "Agree" ($p = 0.049$).

For the five questions about internal and external parasites of livestock, technicians and veterinarians always reported significant and positive changes (see Table 4). For understanding the biology, ecology, and animal health implications of internal parasites of livestock, technicians changed from "Disagree" to "Agree" ($p < 0.001$) and veterinarians changed from "Neutral" to "Strongly Agree" ($p = 0.011$). For ability to

Table 3
Environment, Nutrition, and Body Condition of Livestock

	Technicians (68T)			Veterinarians (64F/64A)		
Question	**Pre**	**Post**	**Pre → Post Change**	**Pre**	**Post**	**Pre→ Post Change**
I can systematically assess the body condition of ***sheep***?	4.6	1.5	S. Disagree → Agree	3.0	1.0	Neutral → S. Agree[1]
I can systematically assess the body condition of ***beef cattle***?	4.6	2.1	S. Disagree → Agree	2.6	1.3	Neutral → S. Agree
I can systematically assess the body condition of ***dairy cattle***?	4.6	1.8	S. Disagree → Agree	2.6	1.4	Neutral → S. Agree
I can systematically assess the body condition of ***horses***?	3.9	2.8	Disagree → Neutral	2.5	1.9	Agree; NS
I understand the reproductive and animal health implications of poor body condition in livestock?	4.3	1.7	Disagree → Agree	2.3	1.3	Agree → S. Agree
I understand the forage characteristics that can influence body condition of livestock?	.2	1.7	Disagree → Agree	3.1	1.8	Neutral → Agree
I can rapidly assess the nutritional quality of rangeland and pasture?	4.4	2.3	Disagree → Agree	3.5	2.8	Neutral; NS
I understand minimum nutrient requirements for livestock?	4.5	2.3	S. Disagree → Agree	3.0	1.9	Neutral → Agree
Mean	4.4	2.0	Magnitude = 2.4	2.8	1.6	Magnitude = 1.2

Note. Pre → Post changes noted are significant at $p < 0.05$ and nonsignificant = NS.
[1] Indicates models that cannot converge due to 0 variance in the postevaluation group where all participants indicate "strongly agree" and changes are considered significant based on no overlap of standard errors.

apply the FAMACHA assessment technique to quantify internal parasite loads of small ruminants and develop treatment recommendations, technicians changed from "Strongly Disagree" to "Agree" ($p < 0.001$) and veterinarians changed from "Neutral" to "Strongly Agree" (note models for veterinarians would not converge due to zero variance in the postevaluation group; changes are considered significant based on no overlap of standard errors). For understanding the biology, ecology, and animal health implications of external parasites of livestock, technicians changed from "Disagree" to "Agree" ($p < 0.001$) and veterinarians changed from "Neutral" to "Agree" ($p = 0.048$). For the ability to apply visual assessments of external parasite loads of livestock and develop recommendations for treatment, technicians changed from "Strongly Disagree" to "Agree" ($p < 0.001$) and veterinarians changed from "Neutral" to "Agree" ($p = 0.013$).

Table 4
Internal (endo-) and External (ecto-) Parasites of Livestock

	Technicians (68T)			Veterinarians (64F/64A)		
Question	**Pre**	**Post**	**Pre → Post Change**	**Pre**	**Post**	**Pre→ Post Change**
I understand the biology, ecology, and animal health implications of internal (endo-) parasites in livestock?	4.4	1.9	Disagree → Agree	2.5	1.3	Neutral → S. Agree
I can apply the FAMACHA assessment technique to quantify internal parasite loads of small ruminants and develop a recommendation for treatment accordingly?	4.6	1.5	S. Disagree → Agree	2.6	1.0	Neutral → S. Agree[1]
I understand the biology, ecology, and animal health implications of external (ecto-) parasites in livestock?	4.4	1.9	Disagree → Agree	2.8	1.6	Neutral → Agree
I can apply visual assessments of external parasite loads of livestock and develop recommendations for treatment accordingly?	4.6	2.0	S. Disagree → Agree	3.4	1.8	Neutral → Agree
I understand the role external parasites serve in vectoring disease pathogens and the associated integrated approaches necessary to managing external parasite infestations and subsequent animal health problems?	4.4	1.8	Disagree → Agree	2.9	1.6	Neutral → Agree
Mean	4.5	1.8	Magnitude = 2.7	2.8	1.5	Magnitude = 1.3

Note. Pre → Post changes noted are significant at $p < 0.05$ and nonsignificant = NS.
[1] Indicates models that cannot converge due to 0 variance in the postevaluation group where all participants indicate "strongly agree" and changes are considered significant based on no overlap of standard errors.

For understanding the role external parasites serve in vectoring disease pathogens and the associated integrated approaches necessary to managing such infestations and subsequent animal health problems, technicians changed from "Disagree" to "Agree" ($p < 0.001$) and veterinarians changed from "Neutral" to "Agree" ($p = 0.033$).

The magnitude of change was two times greater for technicians (i.e., averaging two points on the Likert scale) compared to veterinarians (i.e., averaging one point on the Likert scale; Tables 1–4) regardless of the type of question.

For the open-ended question of "What was the most useful task or topic covered in this training?," 14 participants explicitly stated that the hands-on portions were the most useful (61%). When stratified by job, seven of eight veterinarians (87.5%) and seven of 15 (46.7%) technicians highlighted this value. Other noteworthy responses from a single participant only included parasite testing, body condition scoring and physical exam, insects and internal parasites, understand herd mentality, and the adaptation and living environments of the animals.

For the open-ended question of "How could this training be improved to enhance your knowledge, skills, and abilities?," four participants expressed drawing blood and administering vaccines, three participants expressed separating veterinarians and technicians for some tasks, three participants expressed a desire for more hands-on with horses, and one participant suggested giving handouts prior to allow for review and reduce didactic portions, which could increase hands-on training time.

For the open-ended question of "What additional topics would you be interested in for future trainings?," four participants suggested more hands-on with horses (and these four participants were not the same participants who suggested the same in the question above). Other noteworthy responses from a single participant only included exotic animals, goats, small animal emergency care, blood and laboratory analysis, reproduction, economics and food security, and hands-on hoof trimming. Finally, one veterinarian suggested "more time to go through a case, develop a treatment plan, and discuss pros and cons."

One noteworthy comment from a veterinarian was "I thought it had a pattern of 'brief lecture' followed by 'hands on activity' to promote learning." One noteworthy comment from a technician was "For me, this is spot on, I am a hands-on learner; explain it and let's go do it. That way it actually sticks instead of just talking about it but never actually performing the task."

Discussion

This experiential and integrated training of U.S. Army veterinary services soldiers positively changed knowledge, skills, and abilities in four broad areas: (1) livestock behavior, handling, and restraint; (2) examination and treatment of livestock; (3) environment, nutrition, and body condition of livestock; and (4) internal and external parasites of livestock. Importantly, the magnitude of change was greater for technicians than for veterinarians. This difference suggests that for technicians, this was the introduction of new knowledge, skills, and abilities whereas for veterinarians, this was reviewing familiar concepts and honing existing knowledge, skills, and abilities. Establishing baseline knowledge and skills of participants to align learning objectives specific to groups may better support optimal learning (Vgotsky, 1978) by providing an appropriate level of challenge. The scaffolded delivery approach and support from both subject experts and peers was effective in promoting progression through the stages of conscious competence to improve proficiency and confidence of participants (Keeley, 2021).

The efficacy of the hands-on (experiential) and active-learning approach (Hamilton, 2019) that was facilitated through university and military animal facilities was noteworthy for participants. This emphasis is reflected not only in the questions addressing techniques requiring handling (i.e., restraint, general handling, physical examination, body condition assessment, application of FAMACHA, and assessment of fecal samples) but also in the open-ended responses where a majority of participants (61%) indicated the experiential opportunities enhanced learning. This is particularly salient given that the lack of hands-on training for new soldiers in the U.S. Army Veterinary Services may lead to a lack of confidence that may hinder comprehensive veterinary care (Torring & May, 2014), suggesting that scaffolding learning could lend to the development of conscious competence.

The organization of soldiers in groups during the training also deserves additional consideration. Small groups always included both technicians and veterinarians in order to develop operationally adept teams (Schatz et al., 2017) that would simulate work in a clinic but also enable peer-to-peer learning (Guldberg, 2008) where veterinarians could emphasize topics and techniques based on their substantial training and experience. Interprofessional education, including veterinarians and veterinary nurses or technicians (Kinnison et al., 2011), is recognized in encouraging a greater understanding of the roles and attributes of each and fostering improved collaboration and teamwork to promote effective interprofessional practice (Kinnison et al., 2014). However, both types of participants suggested separating small groups by job types at least for some portions of training. The logic behind this suggestion seems to be rooted in the level of detail desired and/or needed by respective groups where veterinarians may want to delve deeper into the physiology, mechanisms, or theory, while technicians may need less in-depth details and more repetition of task. For example, veterinarians verbally articulated during the training the desire for more discussion about sedation and anesthesia, treatment plan development, and slaughter, whereas technicians in writing expressed more time for hands-on tasks with less lecturing. Thus, this could allow for tailoring learning objectives for each group, addressed independently and collaboratively as appropriate. Adopting a flipped learning approach by providing theoretical content prior to the training days may promote confident skills development (Decloedt et al., 2020) by facilitating increased time for practical application.

It is also important to consider the impetus and vision for this training, which was an unexpected outcome of the LTHET program. In the case of the authors of this manuscript, the LTHET opportunity revealed resources for training and teaching at universities and opportunities for handling animals (Calkins & Scasta, 2021). Through this professional development opportunity, and rooted in rangeland livestock research, the development of critical animal handling and measurement tasks facilitates the opportunity for soldiers to handle a critical mass of patients and hone skills through repetition (Calkins, 2020). Such numbers of livestock at university farms could be compared to caseloads at a veterinary clinic when considering the value of such trainings in terms of animal cases available. The volume of livestock available maximizes the number of opportunities for each participant, whilst reducing impact on any individual animal's welfare, a required consideration for ethical approval of the training. Finally, this learning approach could also be considered case-based learning, which stimulates deep learning, improved clinical reasoning, and increased confidence (Patterson, 2006), with a reflective opportunity for assessment of learning and for participants to employ critical reflection at the end of each day.

Participants made suggestions for future training, many of which included hands-on opportunities, particularly drawing blood, blood laboratory analysis, administering medication, trimming hooves, emergency care, and other species (goats and exotic animals). Future training may also need to include more instruction about zoonotic diseases, of which U.S. Army Veterinary Services may experience an elevated risk (Vest & Clark, 2012). Future training should ensure Army Veterinary Services are prepared to assess for the presence of transboundary animal diseases and investigate unexplained livestock and wildlife deaths that may impact agricultural systems in the United States with the movement of military vehicles and personnel. Additionally, Veterinary Services personnel must evaluate host-nation capabilities to integrate policy with multinational forces. Moreover, they must be prepared to advise commanders on zoonotic disease transmission, provide medical care to local livestock, build relationships with food production facilities, and agricultural and veterinary medical agencies (Department of the Army, 2020). Although Army Veterinary Services does not routinely work with large animals, virtually all tasks performed using large animals as a training model builds readiness in the small animal clinic, for example, performing comprehensive physical exams, venipuncture, hematological preparations and evaluation, and ultrasonography. By utilizing large animals, soldiers are able to repeatedly perform tasks over the course of a few days in quantities greater than or equal to what is achievable over the course of a year in small animal practice, leading to improved proficiency and skill retention. With that said, future efforts should include an evaluation plan and longitudinal data collection to quantify proficiency and sustained skill retention. In addition, we recognize that this study has a relatively small sample size that is constrained by multiple factors including the risk of moving a large group of soldiers away from posts to a single location for training. Finally, we recognize the potential biases of self-reported data and suggest that future training efforts have objective measures of skill acquisition in addition to the self-assessments.

Conclusion

This learning-centric (Williams, 2020) training of U.S. Army Veterinary Services veterinarians and technicians effectively enhanced soldiers' knowledge, skills, and abilities for sheep, cattle, and horse care. The integrated approach of this training that focused on active (Hamilton, 2019) and experiential learning to understand the environment in which these animals exist, the influence of the environment on animal health, how to handle animals, and how to conduct specific tasks and techniques in the context of the 68T ICTL can serve as a learning model for future trainings. Projecting forward, such collaborative training needs continued priority given the U.S. Army's role in stabilization and reconstruction of failed or failing nations, with a focus on agricultural operations via function of the U.S. Army Veterinary Services because such endeavors stimulate agricultural productivity and improve animal and human health, ultimately accelerating stabilization (Smith, 2007). Finally, the role of the U.S. Army Veterinary Services continues to evolve while it serves historic and enduring core functions while endeavoring to be nimble and embrace new roles (Vroegindewey, 2007). Ultimately, this may have potential long-term benefits for military veterinary readiness for addressing emergent roles. Such emergent roles as disease surveillance, food defense, and reconstruction and stabilization with a focus on agriculture require that future training be innovative, multidisciplinary, and capitalize on possible partnerships as demonstrated in this training with agricultural universities, both domestically and abroad. Finally, our teaching model may have applications to other training contexts where repetition of tasks is needed.

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Force Design 2030 and the Challenge of Transformational Learning in the United States Marine Corps

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Abstract

This article examines why the military struggles with transformative learning viewed through the lens of the U.S. Marine Corps' current restructuring plan, Force Design 2030. Other published pieces on Force Design 2030 simply argue for or against the specifics of the plan instead of opening the aperture to investigate why the Marine Corps, and the U.S. military writ large, struggles with transformational learning as an organization. This article looks at the American military's historical predilection for informational learning, which has led to an overreliance on a rigid lessons-learned approach and simply changing what we know instead of reframing problems and changing how we *know* through critical reflection and discourse to fundamentally alter individual and group perspectives. Alternative approaches to transformational learning are suggested in this piece, tempered with an acknowledgment of the military's continued reluctance to challenge the status quo. Readers should take away a better understanding of why dramatic, fundamental changes in the service branches are often met with vitriolic resistance from both inside and outside its ranks.

Transformation is a process, not an event.

—John P. Kotter, Harvard Business School

The very first word in Force Design 2030, the U.S. Marine Corps' (USMC) strategic planning document, is *transformation*, as used in the quote above (USMC, 2020a). Gen. David H. Berger, the 38th commandant of the Marine Corps, ordered fundamental changes to the organization's structure, focus, and capabilities, and called for "sweeping changes needed to meet the principal challenges facing the institution" (USMC, 2020a, p. 1), principally shifting away from the last 20 years of operations in the Middle East and preparing to counter a near-peer adversary in the Indo-Pacific: China. On its face, the USMC's plan for the future appears to bear all the hallmarks of transformative learning—an organization that has learned from experiences, reflected on the adjustments needed, and is on the precipice of a "dramatic, fundamental change" in the way it sees itself and the way it operates in the world (Merriam et al., 2007, p. 130). However, the transformation is far from complete. While on paper, the commandant's vision for the future of his service is beginning to take shape by divesting legacy equipment and restructuring units, not everyone is sold on the idea that the USMC needs to change the way it does business. Retired Marine Corps generals, anonymous active-duty officers, former executive branch officials, and current politicians alike have all engaged in a public rebuke of the plan, calling Force Design 2030 "an unproven concept" (Van Riper, 2022, para. 4) that has caused them to "have valid concerns" (Van Riper, 2022, para. 2) about the direction their beloved Corps is headed (Feickert, 2023).

This article investigates the ongoing challenges military organizations have in effectuating transformational change, as viewed through the lens of the USMC's Force Design 2030 initiative. After introducing transformational learning and its tenets, it looks at both the historical context and current state of learning in the military, and how the services overwhelmingly lean toward informational versus transformative educational practices. This article provides suggestions to alter mindsets and methodologies in how the USMC conceptualizes and pursues transformational change. This article discusses why the military's reluctance to change will extend the timeline, despite a clear and present danger of maintaining the status quo.

Transformational Learning Theory

Mezirow (2009) defines transformative learning as "the process by which we transform problematic frames of reference," or our mindset, to make them more "emotionally able to change" and better prepared to guide future action (p. 116). Transformational learning is distinct from informational learning—the latter changes *what* we know and adds to the information we apply to new contexts, while the former changes *how* we know or how we look at things in the first place (Kegan, 2009). More simply put, transformational learning is about a fundamental change in perspectives, which reframes our outlook on the problem set. In transformational learning theory, there are two dimensions: a habit of mind and a resulting point of view (Mezirow, 2009). According to Mezirow, habits of mind include our mindset or habitual ways of thinking, which are susceptible to influence by assumptions and expectations that become a filter for the way we see the world. For instance, one such habit of mind that Mezirow found in military environments is ethnocentrism, or the predisposition to believe that those outside of one's group are inferior. Mezirow also believes that points of view are comprised of *meaning schemes* that appear as immediate responses, such as emotions, value judgments, and attitudes that shape one's interpretation of the information we are perceiving. Again, in Mezirow's terms of ethnocentrism, the resulting point of view may be a negative attitude toward individuals who are different from our own group. In general, a point of view is more likely to change than a habit of mind because we are more aware of their existence and therefore are more susceptible to feedback from others (Mezirow, 2009).

Mezirow's transformational learning theory has 10 phases that can be categorized into four main components: experience, critical reflection, reflective discourse, and action (Merriam et al., 2007). The first step is experiencing a "disorienting dilemma," or a crisis that "cannot be resolved through the application of previous problem-solving strategies" (Merriam et al., 2007, pp. 135–136). The next steps are to embark on a journey of self-reflection to determine what habits of mind have affected the way we interpret situations, and then engage in critical dialogue, which should include a variety of points of view, especially those that challenge the status quo, in order to come to a better common understanding of the problem and possible alternative solutions. The final step is setting off on a course of action to implement the transformation by looking at future problem sets through the new perspective gained through the process.

Transformative learning, like Force Design 2030, is not without naysayers. Some critics of transformational learning theory believe Mezirow's work is acontextual—his original research in 1978 studied women returning to school after an extended break and lacked any analysis of the subjects' historical and sociocultural background that could add to the analysis of the nature of their transformations (Merriam et al., 2007). Taylor (2000), one of the leading opponents of transformational learning theory, conducted an empirical review of Mezirow's work and found that information specific to each individual could explain inconsistencies, such as why one person may experience a disorienting dilemma that would potentially lead to a transformation, while another person would have the same experience and not change at all. Another broader criticism of transformational learning theory is that it relies on a Western, patriarchal, and predominantly White concept of rational thinking (Merriam et al., 2007). Taylor (2000) again leads the dissent in this area, stating that Mezirow's work

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discounts the role of affective learning and how emotions and feelings must be dealt with before a person can truly participate in meaningful critical reflection. Finally, work in the field of neurobiology has made researchers more aware of implicit memory and the conditioned responses such as habits, routines, or norms that result and may unconsciously influence a perspective of transformational experience (Merriam et al., 2007).

In later work, Mezirow (2009) conceded that context, including "ideology, culture, power, and race-class-gender differences" (p. 119) does play a role in "who learns what and the when, where and how of education," (p. 127) but can be rationally assessed as factors and not necessarily "servants to these masters" (p. 120). He also responded to the notion that his work does not include an accounting of implicit memory; in his view, the critical reflection for true transformation necessarily involves an accounting between the conscious and unconscious so that individuals learn how the latter influences how they see themselves and how they interpret and act to the world around them. In total, the criticism of Mezirow's work can be summed up as pointing out aspects that should be included in the transformational learning process but not fatal flaws in the theory itself.

History of Military Learning

From the organization's infancy, the U.S. military has leaned heavily on informational learning as its primary tool to produce qualified troops quickly and efficiently for combat. Initial or basic training is certainly a disorienting dilemma that results in an individual transforming from a citizen to a soldier, but the process lacks the critical reflection or reflective discourse that falls in line with transformational learning per se—although drill instructors would likely be entertained by a recruit attempting to engage in such a dialogue. During World War I, the U.S. Army discovered that most draftees were lacking in math and reading skills beyond a sixth-grade level, while some were essentially illiterate, and all could benefit from learning the fundamentals of citizenship (Egardner, 1922). In the National Defense Act of 1916, Congress ordered that service members be allowed to receive instruction on general education subjects to increase their military competency but also to prepare them to be better equipped to reintegrate into society as productive members. Military specialists created a program of vocational education in a formal classroom setting over a year, and then quantitatively measured their increase in intellectual maturity by using standardized tests administered both at the beginning and end of the training. Egardner found that the formal instruction resulted in a marked improvement in test scores in all areas: spelling, vocabulary, language, and math skills. However, neither the Department of Defense (DOD) nor Egardner conducted an analysis to determine if the service member's education translated into the reflective and critical thinking the Army was seeking to develop. The program ended after only one school year and one set of participants—like all other education activities in the military, the war department did not see the utility of such an education program after the war ended, and it fell victim to reduced DOD funding (Egardner, 1922).

Just before the Vietnam War, the chief of the Army's education department declared again that the military wanted to produce better-educated men and women to enrich the civilian population when they were done with service, but frustratingly repeated the same methodology his predecessors did 40 years earlier (Strehlow, 1962). In keeping with the military's strict adherence to proscribed courses of study in formal classroom settings and "instruction in fundamental academic subjects" (p. 27), Strehlow (1962) alludes to the importance of self-improvement as a necessity for service members, but only in the context of keeping up with rapidly changing military weapons and equipment, and not to exercise any critical thinking to apply to the increasingly complex nature of war.

In the 60 years since, the U.S. Armed Forces have made moderate gains in adapting adult education principles to improve learning in the military, but still fall well short of the transformational change conceived of in Force Design 2030. The 1970s saw a review of how officers were trained and the recommendation that a professional military education system be developed to produce leaders "capable of making sound judgments" in future fluid and complex situations (Persyn & Polson, 2012, p. 9). In the 1980s, in what is arguably the first substantial attempt at transformational change for the American military, Congress passed the Goldwater-Nichols Department of Defense Reorganization Act in 1986 and established the Panel on Military Education, otherwise known as the Skelton Panel. According to Persyn and Polson (2012), one of the primary goals of these initiatives was to address the ethnocentrism that was rampant between the service branches post-World War II and adversely affecting combined joint military operations. Accordingly, in Goldwater-Nichols (1986), Congress dictated what training officers needed and how that education should be delivered to adequately prepare them to serve in joint service assignments. However, even almost 40 years after its enactment, there are still those who question the validity of the educational reforms of Goldwater-Nichols. For example, Anderson (2023), a retired USMC officer, argues that the United States has not won a war since Goldwater-Nichols because of those "misbegotten reforms [that] laid the groundwork for bloated joint staffs that cannot get out of their own way," and leading to a "Marine Corps that willingly castrated itself in an idiotic new strategy called Force Design 2030" (para. 3). Instead, he argues for less engagement and reflective discourse between the services in joint environments, and a more insular, linear, informational educational path for a warfighter to become "a master of his trade" only by spending "years in the trenches learning his craft" (Anderson, 2023, para. 15).

Current State of Military Learning

Military education today encompasses basic skills to graduate-level professional military education. One methodology used by militaries around the globe is the formal *lessons-learned* process, in which experiences from ongoing or past operations are gathered, reviewed, and widely disseminated in the hopes that other units will learn what has worked and what has not, and then apply those lessons to future operations (Dyson, 2019). However, the effectiveness of this formalized system of managing informational knowledge has flaws. For example, the Swedish Armed Forces bluntly stated that their lessons-learned process was simply "not working" because "few reported observations have been analyzed, validated and subsequently implemented [and] the experiences that been heeded are almost exclusively on a low tactical level" (Hasselbladh & Yden, 2020, p. 486).

Similarly, the services have made attempts to transform military education and incorporate adult learning principles into their curriculums but have gained little ground. For instance, the *U.S. Army Learning Concept for 2015* (Department of the Army, 2011) structurally brought all educational instruction under the supervision of one entity, Army University, in an attempt to merge the concepts of training and education "in a continuum of learning rather than treating the two as distinct, mutually exclusive learning domains" (Persyn & Polson, 2012, p. 10). However, that ambitious initiative has not been fully implemented, let alone effective; there is still no comprehensive or clear approach to military education that sufficiently aligns with adult learning theory and andragogy principles, while the Army marches on and continues to execute its curriculum in a rigidly uniform "one-size-fits-all model" (Pierson, 2017, p. 31). Other examples are two foundational documents that bookended the USMC's release of Force Design 2030, Marine Corps Doctrinal Publication 7, *Learning, and Training and Education 2030* (USMC, 2020b, 2023). Both publications were aimed at transformational changes in the way the USMC views learning and education, including ending the bifurcated view of training versus education and acknowledging the value of instituting a shared perspective of learning. But like the Army, the proscribed modernization of USMC's educational methodologies fall back into the comfortable realm of recommending formal, linear instruction instead of utilizing the "applied science, research, and philosophy of the field of adult learning" to propose real change (McCann & O'Connell, 2020, "MCDP 7's Purpose" section).

One program that demonstrates the military is capable of transformational change in the way the organization approaches learning and education is the Army's development, training, and utilization of decision-support red teaming (Dietz & Schroeder, 2012). Referring to red teaming, Dietz and Schroeder (2012) found that the process brings transformative learning principles such as "full-spectrum (holistic) critical thinking to an operational environment (OE) in an effort to provide commanders with both alternative perspectives and ideas for improving plans" (p. 29). In an uncharacteristic change of pace for military learning, Deitz and Schroeder (2012) believe red teaming encourages diversity of thought, collaborative discourse, and critical thinking that is purposefully aimed outside of the doctrinal, one-size-fits-all mindset that usually plagues military planning. They also found that red teaming schools depart somewhat from the military norm of the traditional, highly structured, informational methodology of learning: classes "are conducted in a roundtable, open discussion style that facilitates and encourages dialogue" with the normal deference for respect between participants of different ranks but "not to inhibit the free flow of ideas" (p. 31). Expansion of these red teaming concepts, aimed at inspiring the kind of critical inspection and reflective discourse that are the hallmarks are transformational learning, could assist in all facets of military problem-solving—both as directed toward external threats such as those described in Force Design 2030 as well as internal challenges such as racial and gender inequality—and lead to the transformative change military leaders in learning other documents have so far failed to inspire (Upward, 2022).

Ways To Transform Military Learning

To engage in transformational change, military leaders should embrace the adult learning principles they purport to employ in their doctrine like *Learning and Training and Education 2030* to truly transform the organization they aspire to and envision in Force Design 2030. Zacharakis and Van Der Werff (2012) describe creating such organizational learning by encouraging a working relationship between adult educators and the military to improve critical thinking skills and increase the overall intellectual prowess of service members. To accomplish this goal, history shows that educators cannot be tied to only customary military teaching methods or bound by traditional adult education principles.

For instance, McCann and O'Connell (2020) suggest that MCDP 7 should be revised to go "beyond previous conceptions of learning" (para. 3) and the current tendency to tell, not show, the benefit of critical thinking. To avoid the danger of "cloning," or producing leaders who think identically to their predecessors, they suggest that the USMC encourages curiosity and cultivates an environment that values "diversity of thought, study, and practice" (para. 7). Acknowledging the repeated failure of military organizations to actually effectuate change, Dyson (2019) used a qualitative literature review to focus on dynamic organizational capabilities and suggests best-practice improvements to the military's formal lessons learned program. His research focuses on the necessary conditions for the organization to avoid stagnant silo-thinking and support knowledge transformation; in other words, to challenge the bureaucratic status quo that serves as a barrier to the integration of new and existing organizational knowledge. Pierson (2017) proposes individually tailoring instruction for service members, with military training and professional education working in consort with one another in a symbiotic relationship under the umbrella of education. He suggests a feasible framework utilizing both the competency-based education approach and the experiential learning model to establish an effective adult learning environment, complete with opportunities to conduct self-reflection and meaningful collaboration to solve problems.

Alternative approaches to transforming learning may seem too radical for the usually predictable traditional views of military education. Nonetheless, they should be considered as unconventional thinking to provide inspiration, if not methodology, to both accurately measure the capability to, and then effectively institute, fundamental organizational change. For instance, Buechner et al. (2020) believe that collective transformation should be defined as a "shared worldview shift that is grounded in a shared experience" (p. 87) and emphasize the role the initial experience plays in transformative learning for the individual who is enduring it. As previously discussed, the shock and awe of basic training or combat can produce the kind of disorienting dilemma or crisis situation that often creates shared hardship and can produce the contrasting feelings of liminality and community, or *communitas*, which this research shows has a positive effect on setting the proper conditions to achieve collective transformation. Of note, the subjects of the qualitative study conducted by Buechner et al. (2020) are five groups of individuals who have survived distressing chapters in their lives, including military veterans returning from combat who participated in holistic retreats. In some cases, those participants reported that they had personally grown from their unpleasant or unsettling experiences and found a comforting community along the way that could be used as an impetus for change. Part of the radical approach suggested by Buechner and his colleagues is to use intentional somatic development techniques because it

> [m]akes major organizational transformations possible because it requires disengagement from the organization's historical self, thus creating an opening through which the leaders can construct a new operational shape. The organization can then embody new practices that will sustain, and possibly advance, the organization. In other words, collective transformation begins with an awareness of what the organization already embodies, continues with the use of imagination to envision the future, and concludes with a commitment to using intentional practices to strategically create a life-giving and sustainable organizational shape. (p. 100)

Although the feeling of communitas can be fleeting, Buechner et al. (2020) found it can be a tipping point to be exploited because from it "shared concepts can emerge, including an organizational vision, a common sense of purpose, and a strategic framework for purposeful action" (p. 101).

Another nontraditional approach to transformational change is proposed by Kasl and Yorks (2016), who used an epistemology approach to posit that empathetic connection is a critical component of organizational change in diverse groups. The barriers to creating the empathy required for transformational change can be categorized through three "dimensions of difference," such as (1) relational power, or how power is distributed in the group; (2) hegemonic embeddedness, or how aware individuals in the group are aware of their personal relationship to power; and (3) emotional valence, or how strong someone feels about new learning (Kasl & Yorks, 2016, pp. 7–9). Given the antagonistic discourse that is essential for transformational change, and as seen in the discord that surrounds Force Design 2030, critical reflection and discussion about all three dimensions of difference could conceivably help overcome contentious divides, especially considering the military's cultural norm of ethnocentrism and its unconscious "internalized hegemony" that convinces individuals that their point of view is "the right way to be" (Kasl & Yorks, 2016, p. 7). However, if history is any indication, military culture remains strongly rooted in tradition and general customs and practices unlikely to be willing to create safe spaces to foster the kind of empathic connection necessary to encourage both personal learning and organizational change in diverse groups in this manner.

Before engaging in any traditional or alternative approach to organizational change, the military might be best served to assess how transformational learning currently takes place within individual service members. Wiley et al. (2021) saw a need for a better method to "operationalize" (p. 403) such an assessment and devised a new quantitative approach to "allow for a deeper understanding of how, when, and why deep reshaping of self takes place" (p. 400). Using the 17 scales in the Belief, Events, and Values Inventory (BEVI) and mapping the results to Hoggan's (2016) self-constructive dimensions of transformative learning as a backdrop, a composite score is created that researchers propose is a more effective measure of transformational learning than any other technique to date (Shealy, 2016; Wiley et al., 2021). The value of this approach is that it provides a measurable methodology that is applicable in a variety of contexts outside of higher education, including the military which historically has shown a propensity for "data-driven learning" and using standardized tests that produce tangible numerical results to evaluate educational effectiveness (Egardner, 1922; Schatz et al., 2017; Strehlow, 1962).

Military's Reluctance to Transform

Regardless of what changes are necessary or what form the transformation takes, history has shown that like a war of attrition, change in the military is going to be painfully slow—partially because of the "monolithic bureaucracy" of government agencies but also because of the organization's stubborn reluctance to change (Zacharakis & Van Der Werff, 2012, p. 94). Tagg (2018) provides a realistic time frame required for truly transformative change through the lens of "System 1" and "System "2" thinking made famous by Kahneman (2011). Tagg explains that students are products of the school system they have been raised in, and therefore have been primed over the course of their lives to accept and use information in a certain way. According to Tagg (2018), the educational model predominant in Western culture primarily utilizes mindless, unconscious rote learning (System 1) evaluated by timed standardized tests, as opposed to the kind of meaningful, conscious reflective engagement (System 2) required for true transformational learning. Historically, the military has doubled down on the linear, informational style of learning and testing to educate the young adults joining its ranks (Egardner, 1922; Strehlow, 1962). As such, changing their perspective—the goal of transformative learning—will necessarily take time to fundamentally alter those mental schemas borne from years of being subjected to educational techniques that were built for efficiency bolstered by mindless learning (Tagg, 2018).

To that end, Hasselbladh and Yden (2020) note that while there have been revolutions in military affairs that have fundamentally transformed the way armies fight, there has not been a corollary transformation in the way armies learn. For instance, using recent international operations such as Afghanistan and Iraq as case studies, the authors question the validity of the military's lessons-learned process that, as previously discussed, rarely results in any change being implemented anywhere in the organization above the tactical level. According to Hasselbladh and Yden (2020), when change does result from the lessons-learned program, it is almost always informational in nature and decidedly not transformative. Comparing the military to other large-scale formal organizations, Hasselbladh and Yden's research hypothesized that while the military shares certain generic traits with these entities, it has even more constraining characteristics that make it less conducive to organizational change. They found that the military's collective learning style is highly controlled and dictated by doctrine and standard operating procedures; it is too rigid, formal, and completely counter to the environment necessary to be dubbed an effective learning organization. As such, Hasselbladh and Yden (2020) concluded that a transition to a more fluid, transformational approach to learning in the military would contradict the organization's inherent tendency to "impose order on chaos" (p. 478)—that is, predictable and repeatable lessons that allow the individual to apply a bias for action at the point of friction and despite the fog of war.

Despite this rebuke, the U.S. Navy's old adage "don't give up the ship" comes to mind—the military should not cease all attempts to engage in meaningful transformational change simply because of its "bureaucratic character and specific task environment" (Soeters, 2022, p. 480). In that vein, Soeters (2022) penned a rebuttal to Hasselbladh and Yden's 2020 article, cautioning politicians and generals alike would use their article as "scholarly ammunition" (p. 481) as an excuse not to actively seek improvements in the constant learning the military publicizes it is pursuing like Force Design 2030. Instead, Soeters discusses the value of *double-loop learning*, which investigates the fundamental beliefs of an organization, and how it can work in conjunction with, and not at the expense of, *single-loop learning*, which is akin to the military's lessons-learned approach of just repeating and then improving existing practices. Although Hasselbladh and Yden (2020) fail to examine why the military would want or even need to embark on a journey of organizational change, Soeters (2022) believes it is an imperative inquisition and action for the military. Citing other organizations that need to constantly change to keep pace or get ahead of the pack, Soeters opines the military similarly needs to continue to transform using *double-loop learning* to maintain American hegemony against near-peer adversaries and meet the demands of modern warfare that is increasingly volatile, uncertain, complex, and ambiguous.

Conclusion

The military's disorienting dilemma demanding transformational change has already occurred: Gen. Robert Neller, the 37th Marine Corps commandant, assessed that "the Marine Corps is not organized, trained, equipped, or postured to meet the demands of the rapidly evolving future operating environment" (USMC, 2020a, p. 2). But transformational learning and organizational change cannot be simply decreed or ordered—it must be cultivated and inculcated into the USMC's culture as the norm, not the exception. It is not enough for military organizations to say *what* will change and just soldier on; for buy-in from the lowest ranks to the highest generals, service members must know the *why* and feel a part of the *how* to reframe problem sets and create long-lasting, effective change. As history shows, the military's habit of mind is its incessant need for informative-only learning, producing uniformity in thought, word, and deed that, in turn, is stymying the diversity of thought necessary for critical reflective thinking and substantive reflective discourse to change its collective perspective. To counter the organization's long-standing reluctance to change, which manifests in negative immediate responses, emotions, and value judgments that have surrounded attempts at transformational change like Force Design 2030, the military would be best served to enhance current nontraditional military education programs and even wade into alternative approaches to transformational learning. In the end, an organization as zealous about its heritage as the USMC must overcome meaning schemes to ensure its members understand that transforming the force does not necessarily mean exorcising the service's very soul. It may take time and effort, but the future fight demands the transformation Force Design 2030 calls for.

Author's note: *The views presented are those of the author and do not necessarily represent the views of the Department of Defense or the U.S. Marine Corps.*

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Upcoming Conferences of Note

January 9–11, 2025: Lilly National Conferences, Teaching and Learning

San Diego, CA

https://www.lillyconferences-ca.com/

This conference provides opportunities for the presentation of the scholarship of teaching and learning. Faculty and administrators at various stages in their academic careers come from across the United States, representing nearly every discipline found in higher education.

January 14–17, 2025: Future of Education Technology Conference (FETC)

Orlando, FL

https://www.fetc.org/

FETC 2025 will host hundreds of sessions across eight distinct tracks that will spark ideas and inspire motivation. Tracks include district leaders, school leaders, classroom leaders, IT leaders, coach leaders, inclusion leaders, sports leaders, and library leaders.

April 5–8, 2025: Higher Learning Commission Annual Conference

Chicago, IL

https://www.hlcommission.org/Programs-Events/conference.html

Held annually in the spring in Chicago, the conference offers learning, professional development, and networking opportunities for Higher Learning Commission members.

May 18–21, 2025: The American Council on Education's Annual Convention and Legislative Summit

Washington, D.C.

https://convention.acec.org/

This conference takes place every spring with over 1,600 attendees participating in educational sessions, congressional appointments, and networking events.

June 4–5, 2025: EduData Summit

Singapore

https://insights.qs.com/registeredudatasummit2025

The EduData Summit is a premier forum for data-driven educators. Learn and share best practices regarding big data, predictive analytics, learning analytics, and education.

June 6–8, 2025: The Teaching Professor Conference

Washington, D.C.

https://magnapubs.com/conferences/2025-teaching-professor-conference/

This conference focuses upon practical, evidence-based tools and practices to help instructors excel in the classroom. The Teaching Professor Conference is your opportunity to dive into effective teaching practices, enhance student learning, and join a supportive community of fellow faculty members who share your same challenges.

July 22–25, 2025: Hybrid, Faculty Development Forum

Fort Leavenworth, KS

This conference is a biennial symposium to enhance the Army's faculty development enterprise.

Call for Papers

The *Journal of Military Learning* (*JML*) is a peer-reviewed, semiannual publication that supports efforts to improve education and training for the U.S. Army and the overall profession of arms.

We continually accept manuscripts for subsequent editions with editorial board evaluations held in April and October. The *JML* invites practitioners, researchers, academics, and military professionals to submit manuscripts that address the issues and challenges of adult education and training such as education technology, adult learning models and theory, distance learning, training development, and other subjects relevant to the field. Submissions related to competency-based learning will be given special consideration.

Submissions should be between 3,500 and 5,000 words and supported by research, evident through the citation of sources. Scholarship must conform to commonly accepted research standards such as described in *The Publication Manual of the American Psychological Association*, 7th edition.

Do you have a "best practice" to share on how to optimize learning outcomes for military learners? Please submit a one- to two-page summary of the practice to share with the military learning enterprise. Book reviews of published relevant works are also encouraged. Reviews should be between 500 to 800 words and provide a concise evaluation of the book.

Manuscripts should be submitted to usarmy.leavenworth.tradoc.mbx.armyu-journal-of-military-learning@army.mil by 1 April and 1 October for the October and April editions respectively. For additional information, send an email to the address above.

Author Submission Guidelines

Manuscripts should contain between 3,500 to 5,000 words in the body text. Submissions should be in Microsoft Word, double-spaced in Times New Roman, 12-point font.

Manuscripts will use editorial style outlined in The Publication Manual of the American Psychological Association, 7th edition. References must be manually typed. (The automatically generated references employed by Microsoft Word have proven to be extremely problematic during conversion into final layout format for publication, causing delays and additional rekeying of material.) Manuscripts that arrive with automated references will be returned to the authors for compliance with submission requirements. Bibliographies will not be used and should not be submitted with manuscripts.

Submissions must include a one-paragraph abstract and a biography not to exceed 175 words in length for each author. Such biographies might include significant positions or assignments, notes on civilian and military education together with degrees attained, and brief allusions to other qualifications that establish the bona fides of the author with regard to the subject discussed in the article. Do not submit manuscripts that have been published elsewhere or are under consideration for publication elsewhere.

Authors are encouraged to supply relevant artwork with their work (e.g., maps, charts, tables, and figures that support the major points of the manuscript. Illustrations may be submitted in the following formats: PowerPoint, Adobe Illustrator, SVG, EPS, PDF, PNG, JPEG, or TIFF. The author must specify the origin of any supporting material to be used and must obtain and submit with the article permission in writing authorizing use of copyrighted material. Provide a legend explaining all acronyms and abbreviations used in supplied artwork.

Photo imagery is discouraged but will be considered if it is germane to the article. Authors wanting to submit original photographs need to do so in JPEG format with a resolution of 300 DPI or higher. Each submitted photo must be accompanied by a caption identifying the date it was taken, the location, any unit or personnel in the photo, a description of the action, and a photo credit specifying who took the photo. Captions should generally be between 25 and 50 words.

The Journal of Military Learning (JML) will not consider for publication a manuscript failing to conform to the guidelines above.

The editors may suggest changes in the interest of clarity and economy of expression; such changes will be made in consultation with the author. The editors are the final arbiters of usage, grammar, style, and length of article.

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