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Army University Press

Welcome to the April 2022 edition of the *Journal of Military Learning* (*JML*). This edition includes manuscripts with a very diverse group of topics and authors from the U.S. Air Force, U.S. Army, U.S. Marine Corps, and Portuguese Navy, and from academic institutions in the United States, Portugal, Puerto Rico, and Brazil. I hope you enjoy this selection of articles and I encourage all our readers to submit manuscripts for publication consideration.

Dr. Keith R. Beurskens
Journal of Military Learning
Editor in Chief

I would also like to bring your attention to the Conference List in this issue and note the Army University Symposium scheduled for 19–21 July 2022. The symposium theme is "Modernizing Military Learning." The event is hybrid with an in-person group (by invitation) at the Lewis & Clark Center, Fort Leavenworth, Kansas, and others invited to attend online. In-person attendance is limited due to the ongoing pandemic.

The *JML* brings current adult-learning discussions and educational research from the military and civilian fields for continual 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. A detailed call for papers and manuscript submission guidelines are found at https://www.armyupress.army.mil/Journals/Journal-of-Military-Learning.

Peer Reviewed

Improving After Action Review (AAR)

Applications of Natural Language Processing and Machine Learning

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Abstract

After action reviews (AARs) are used within the military and organizations to assess events and their corresponding training outcomes. These team discussions provide a learning-focused method to assess performance and analyze failures or possible improvements to future events. Useful information is frequently embedded within these AARs in the form of unstructured text and speech. This article proposes a solution to analyze and trend AARs digitally. We discuss solutions to capture data using hand-held devices. Such devices allow for audio ingested into a data pipeline where speech-to-text processing occurs. Audio processing operates by identifying primitive language components such as phonemes paired with contextual modeling of their relationships to identify the most likely textual output. We then discuss the conversion of the speech to text and the application of Natural Language Processing (NLP) to enable analytics. NLP techniques uncover semantic patterns in unstructured text which then are correlated with team performance measures. Such trends allow for optimization of military training courses through revealing success-promoting factors between AAR and team performance.

After action reviews (AAR) have been the foundation of the U.S. Army training life cycle for decades. These reviews function as collaborative posttraining meetings to allow the team to engage in self-learning and self-correction

(Morrison & Meliza, 1999). The meeting, typically led by a unit leader or facilitator, focuses on asking the group (a) what was planned during the training, (b) what occurred, (c) why the events unfolded the way they did, and (d) what should be modified before the next training. These retrospective sessions provide an opportunity for soldiers to evaluate previous performance. Analysis of multiple AARs over time may further result in identification of training deficiencies and team improvement opportunities. Aggregated results and analysis of AARs within a specific organization may further yield organizational insights. In order to enable analysis of multiple AARs over a longer time frame, both data collection and analysis must be addressed.

Capturing AAR data digitally poses several challenges. AARs are performed in a highly verbal manner. AAR processes utilize open-ended questions, involve the entire team, and may be formal or informal. The AAR discussion and outcome may be manually documented once complete. Although there are standards that should be followed during an AAR, inconsistencies will undoubtedly exist between facilitators and across units. The verbal nature and varying structure of AARs together make them difficult to document.

Electronic data directly captured during the AAR (using voice-to-text technologies) can be analyzed utilizing algorithms such as Natural Language Processing (NLP). For example, an algorithm could automatically identify that a shortage of training equipment could be of concern based on certain phrases and words utilized across multiple AARs. Repeating words or phrases can be visualized in electronic dashboards to provide insight into AARs and underlying training successes or failures.

NLP emerged out of the 1950s from the intersection between linguistics and artificial intelligence (AI). It is utilized to extract information from text sources such as documents (Nadkarni et al., 2011). Searching the internet for content is an everyday example of NLP. NLP broadly works by creating a mathematical representation of text, which can then be analyzed. However, to the end user, these mathematical details are hidden. There are multiple techniques within NLP to include sentiment analysis, topic modeling, text classification, and text clustering. The most common NLP approach is classifying text.

Text classification occurs through the calculation of word frequencies in a text field. These word frequencies can be used for word combinations linked to each class label to be captured. For instance, a model could classify a written review as positive if the review consists of words such as "good," "very," "happy," "liked," "again," or "enjoyed." In contrast, reviews containing words such as "poor," "never," "boring," "unsatisfied," "little," or "not" would be classified as negative. More advanced NLP techniques can analyze the inferred context and meaning of words by utilizing mathematical vectors. These vectors are calculated by learning each word's conditional probability of occurrence given all other words in a text field, thus quantifying each word's context. Textual clustering, or the groupings among relevant semantic words or phrases, can be captured through grouping textual vectors by proximal distances from other clusters. Additionally, an embedded vector can be compared against another for similarity through applying cosine distance to both vectors.

Although the Pentagon has recently invested $2 billion into AI capabilities, there have been few documented applications of NLP within the Department of Defense (Millman, 2018). In the early 2000s, the military's main advancement in NLP was shown through a voice interactive device project which focused on voice-to-text translation. The primary purpose was to free up soldiers' hands while accessing or storing data in a computer database for such tasks as vehicle troubleshooting or paperless documentation of diagnostic information (Rodger et al., 2001). In May 2012, the Defense Advanced Research Projects Agency launched the Deep Exploration and Filtering of Text (DEFT) program to enable defense analysts to discover implicit patterns in language (Onyshkevych, 2012). More recently, the Department of Defense introduced the Joint Artificial Intelligence Center to standardize AI practices, tools, data sharing, and technology across the military. In the Joint Artificial Intelligence Center, the Operations Center Cognitive Assistant project intends to increase accessibility and detection of troops' urgent calls using NLP approaches to efficiently label verbal communications by the degree of urgency (Freedberg, 2019).

This article will demonstrate the value of NLP approaches when applied to course surveys and narratives. Multiple techniques will be utilized to include topic mod-

Kim Cates completed an MS in data analytics from Seton Hall University in 2019. She has an extensive background in research, machine learning, statistical modeling, and neuroscience. While working as a data scientist at KBR Incorporated, Cates has focused extensively on capturing trends from unstructured text using natural language processing (NLP) centered on building predictive maintenance models across various aircraft platforms. Kim intends to apply her expertise in NLP to build optimized workflow systems for defense in logistics applications.

Marc Banghart, PhD, has over twenty years of experience within the defense and intelligence sector and is a chief engineer for KBR Incorporated. He earned his PhD in industrial engineering in 2017 and holds graduate degrees in both computer engineering and systems engineering. In his current technical role, he applies artificial intelligence, machine learning, and cognitive capabilities to complex systems within the defense sector. He has served on various boards to include the Institute of Electrical and Electronics Engineers Accelerated Stress and Reliability Conference and is a past chair of the American Society for Quality Reliability and Risk Division. He currently serves on a PhD committee at Mississippi State University researching the application of model-based systems engineering to complex systems.

Alexander Plant is a diversified technical problem solver with experience in software engineering, cloud engineering, Agile practices, and distributed systems architecture. He has worked on projects large and small ranging from training delivery and data engineering for bespoke defense platforms to financial transaction systems and payroll integrations for Fortune 500s. He is passionate about open-source software and loves finding simple, composable solutions to complicated problems.

eling. Topic modeling will provide insight into the trends of word distributions as they vary from each topic. Topics can be used for identifying word-groups affiliated with different courses and outcomes. Furthermore, effective modeling of course success through the application of machine-learning models and neural networks to quantified text values will be summarized. Lastly, this article will include a proposed infrastructure for AAR data storage and management using scalable, cloud-native solutions, and discuss how these relationships will inform efficient training design.

Methods

Data Collection

The analysis utilized a dataset available from Coursera to demonstrate the capabilities of NLP. The Coursera data set was selected due to COVID-19 restrictions that prevented data capture as originally planned. The data set included course review text, the rating of course, and the type of course. The course review was an unstructured text field while the course rating was on an ascending Likert scale of 1 through 5. With minor modifications, the techniques applied in this article can easily apply to an AAR data set.

The course review's text was preprocessed before applying any text analysis. Unnecessary characters were removed along with any meaningless words. Irrelevant characters involve any single characters or special characters such as "!," "a," "$," or "-." Removed words are most often characterized by words in prepositional phrases such as "to," "the," "in," and "from." Additionally, words were transformed to their base word or "stem" through a process called stemming. For instance, the words "repairing" and "repaired" would be reduced to "repair." In effect, noise is filtered from the model by removing redundant words while power is increased by adding to words' semantic value.

Data Engineering

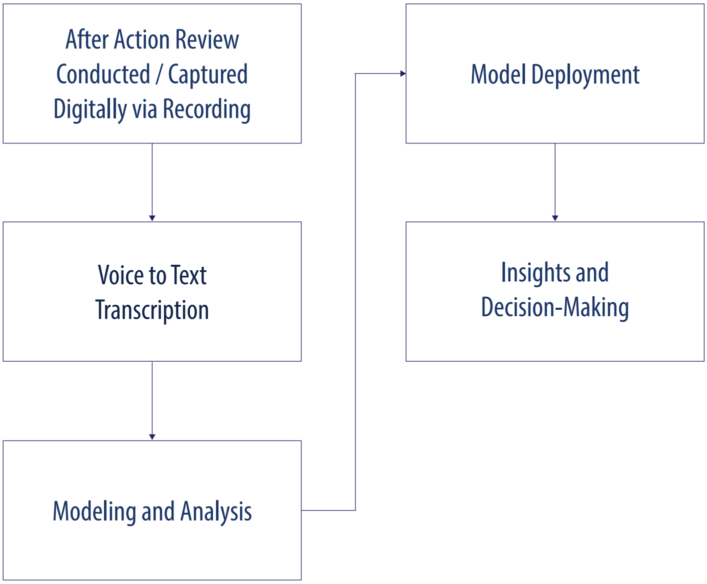
Storage. The use of cloud-native storage and accessible computational resources can provide a cost-efficient and convenient method of storing unstructured AAR data. Recent developments have simplified the creation of a big data solution for the aggregation and processing of large sums of data. Decades ago, it often required excess hardware like mainframe computers and massive parallel storage. Even with innovative frameworks like Hadoop, maintenance of a fleet of commodifying hardware and specialized configurations was still needed. The advent of web-based object stores and managed analytics offerings through vendors like Azure and Amazon Web Services (AWS) have had a pivotal impact on big data efforts.

The cornerstone of such an approach is an HTTP-based object store such as AWS Simple Storage Service (S3) or Azure Blob storage. Such services provide a highly durable and available storage facility for files of varying magnitudes. These providers bill on a discrete storage and transfer basis as opposed to paying for possible usage as in typical capital expenditure scenarios, which reduces administrative and financial burden. Since files are accessible over the internet via a typical HTTPS connection, these services enjoy wide support across many development platforms. In this scenario, AWS S3 would function to store individual AARs in an access-controlled bucket for later analysis. The AAR would be recorded by a bespoke application and transmitted to AWS S3 by the laptop or tablet-based field device in an asynchronous manner based upon the availability of a WAN connection.

Analysis. Once an AAR recording is in an object store format, a cloud provider can pair its extract, transform, and load (ETL) data integration process with streaming transformation tools to cleanse the data. Services such as AWS Glue and Azure Data Factory permit the creation of automatic data extraction, cleaning, and movement jobs. Other preanalytic tasks are integrated into the ETL process. Speech-to-text, for instance, can be accomplished using AWS Transcribe in place of commercial offerings that might not meet Department of Defense-mandated security standards. This opens the possibility of easing the data capture process by allowing voice recording capability instead of cumbersome typing on touchscreen keyboards. Tags can also be applied based on the source and content to further categorize and enrich the data. AAR data would notionally be converted to text, tagged appropriately, and then stored in an adjacent AWS S3 bucket for processing.

A cloud provider's managed analytics service offerings can subsequently be used to perform a wide range of analyses ranging from typical statistical methods to machine learning. Data scientists typically develop NLP solutions in interactive Python environments known as notebooks using machine learning frameworks such as Keras, Scikit-Learn, and TensorFlow. AWS SageMaker and Azure Machine Learning provide managed notebook packages for the development of these solutions. Our typical machine learning workflow for productionizing these types of solutions involves the use of SageMaker for not only development but also compilation and deployment. SageMaker's additional components like Neo and Hosting Services facilitate this by providing cross-compilation and managed API endpoints for machine learning models respectively. These deployment capabilities enable not only programmatic access over a network-accessible API but also model deployment to edge devices like low-power servers and mobile devices. SageMaker is ideal in that it would allow for AAR data to be read into its analytics platform. Within this platform, NLP approaches are developed for uncovering semantic patterns in text. Once robust NLP models are established, SageMaker provides automated analytics jobs to be run and stored into their respective data warehouses. NLP results may then be read into a business intelligence (BI) tool to generate visualization. For example, data

Figure 1
The Notional After Action Review (AAR) Process



could be read from AWS S3 bucket into SageMaker where the NLP preprocessing will be executed. The NLP output would be stored back into AWS S3, which would then populate a prebuilt AAR dashboard within Kibana. Within this infrastructure, the dashboard would be updated automatically as the AAR data is stored.

Consumption. Techniques used to consume processed data and ML models can vary dramatically depending upon user needs and operational agility. Models' exposure via remotely deployable units and RESTful APIs means that a variety of solutions can consume the models and data, not the least of which are the usual crop of BI applications like Tableau and Power BI. Custom web and mobile apps can be developed to leverage more advanced charting, integration, and formatting capabilities afforded by full-featured development environments. For this application, a simple web application would be developed to query AWS Lambda APIs exposed by AWS API Gateway to facilitate search and sieve capabilities on transcribed AAR data and the actionable insights they yield. Periodic reporting and stakeholder dashboards would be developed using Tableau linked to these same APIs (or directly to the object store in cases where additional capabilities are required). So long as access to the AAR artifacts is highly available and governed, the sky is the limit—augmented reality, geographic information systems, and other exotic applications all integrate with this notional system as depicted in Figure 1.

NLP Approaches

Modeling Course Satisfaction

Course satisfaction was modeled using both machine learning models and a convolutional neural network (CNN). Both approaches transform the processed text into numerical values but differ in their transformation operations. A dictionary, also referred to as a corpus, is created before applying these operations to the text field. A corpus lists all the keywords to be analyzed in the text field of interest. These keywords are usually determined by some minimum word count threshold. For this specific application, the words had to occur at least a hundred times to be considered part of the corpus. Words not meeting this threshold are removed from the text field to reduce variance. The models are trained using these text values as an input and course rating as the output. During the training process, the models' weights are optimized to generate predictions consistent with the actual course rating. The model iteratively aims to reduce the error between predicted course rating and actual course rating, or loss, through backward propagation.

Before training the machine learning models, the text is transformed into numerical values through term-frequency inverse-document frequency (TF-IDF). TF-IDF captures the term frequency (TF), or the total times a term occurs in a document. Inverse-document frequency (IDF) resembles how many documents consist of the same term. The TF-IDF value emerges through the product of TF and IDF. This value increases by the number of times a word occurs in a document and is stabilized by the number of documents that contain that word. TF-IDF allows not only for word frequencies to be captured but also controls for the words that commonly occur.

The outcome of the TF-IDF transformation is a matrix in which each column represents a word in the corpus and the rows correspond to individual surveys. The values within each cell are the word frequencies, or the product of TF and IDF, for each word. The machine learning models are then trained on this word frequency matrix as the input with course rating as the output. Logistic Regression, Naïve Bayes Classifier, Support Vector Machine Classifier with a Linear Kernel, and Random Forest Classifier were trained on the word frequency matrix extracted from the review's text field.

In contrast, the neural network model maps each word in the corpus to a vector of continuous numbers through an embedding layer. The embedding layer functions to identify similarities among discrete variables, or in this case, words. Before words are fed into the embedding layer, each word is transformed into a unique integer, or a "token," that will function as its index in the embedding layer. The word vectors are generated by a superficial densely connected layer. The embedding layers work to iteratively generate the conditional probabilities that other words will occur given the presence of the input word. Therefore, the output word vector is representative of the conditional probability a word occurs given all the other words in the corpus. Because of this, embedding layers are often used to visualize semantic similarities among words. Consequently, calculating the cosine distance between two-word vectors functions as a measure of similarity between two words. The t-Distributed Stochastic Neighbor Embedding (t-SNE) technique was applied for reducing the words vector from 50 to two. The words, or two-dimensional vectors, can be visualized as a scatterplot in which semantically similar words are illustrated by their proximity to each other. Each word vector in the review string forms the input matrix to the neural network. All word vectors are zero-padded to 50 to make all input matrices the same size. Following this, these matrices become the input to the convolutional layer. Within the convolutional layer, several nodes function as a "filter." These filters are 3x3 matrices that convolve the matrix. The dot product of the convolving filter and the input word matrix form the output of the convolutional layer. A max-pooling layer and drop-out layer are subsequently applied to control for increased bias or overfitting. The output of these layers is then fed into a densely connected layer where the prediction output is generated.

The ordinal variable, the course rating, was preprocessed using a dummy coding approach. In this approach, each rating was binary encoded resulting in five columns where a "1" was used to represent the ranking. The columns would then be "0" where the ranking was not present. The output layer consisted of a densely connected layer with an output shape of five to represent the five-point rating scale. A sigmoid activation function was used to reduce the predicted probability to either a 0 or 1. The binary cross-entropy loss function was applied to this output to effectively update model parameters from these predictions.

A scatterplot represents the reduced two-dimensional output of the word vectors from the embedding layer. The word vectors are reduced from 50 dimensions to two dimensions (x and y) using the t-SNE technique. The outcome scatterplot conveys how the embedding layer in the neural network captures semantic similarity among words. For instance, words such as "research" and "study" are close to one another just as "suggest" and "recommend" are overlapping another.

Results

Machine Learning Models

Overall, the machine-learning models demonstrated above-average predictability of course satisfaction. That is, the models averaged 75% accuracy in predicting course satisfaction. The Logistic Regression model performed superior at 77% accuracy while the Random Forest Classifier exhibited the lowest predictability at 73%. When looking more closely at each rating's accuracy in the Logistic Regression model, it is apparent that middle rankings did not perform as well. The more evident rankings such as 1 or 5 yielded more robust results and is most likely due to definitive co-occurring words associated with a poor rating or a great rating. In contrast, ratings 2 through 4 do not consist of distinguished language that is unique to their rank. When it comes to AARs, it is important that the language captured consists of enough variance for machine-learning models to effectively capture differences in training performance. This is contingent on the scale of training performance along with the data size captured.

Convolutional Neural Network

The CNN performed overall better than the machine-learning models with an average prediction accuracy of 95%. This increase in predictability of the CNN compared to other models is most likely due to the differences in processing text. Contrary to traditional machine-learning models, the embedding layer captures semantic similarity among words while the TF-IDF matrix only allows for patterns in co-occurring words to be modeled. In a more defined sense, the CNN can detect a range of similar words occurring together due to their similarity and therefore, considers synonyms to have the same impact on the model's output course rating. In contrast, the TF-IDF does not reflect the interdependence of synonyms. However, the CNN class-by-class results are consistent with machine-learning models' outcomes revealing that the course ranking of 5 performing superior to other rankings.

Linear Discriminant Analysis Interpretation

Topic modeling through Linear Discriminant Analysis (LDA) allows for underlying contexts in which language may be used in the unstructured text analyzed. While machine-learning models aim to extract patterns in the text linked to preexisting groupings of course rating, LDA discovers naturally occurring groupings. These hidden contexts can then provide more insight into model performance. By referring to topics generated as shown in Figure 2, five general themes emerge from the reviews. Topic #0 represents overall extremely positive reviews of the course. Topic #1 consists of extremely positive reviews that are associated with a machine-learning course. Topic #2 captures positive reviews that are linked to an introductory Python course. Topic #3 does the same but focuses on an overall data course. Lastly, Topic #4 contains good reviews, but the good reviews are less positive than those captured in Topic #0. Overall, these core groupings of words extracted from the LDA algorithm shed light on the key text patterns in the course reviews. Considering the inconsistent accuracies from the models' predictions per course rating, it is not surprising

Figure 2

Core Topic Groupings of Words Extracted through LDA Algorithm

Topic #0: course learn lot thank good love learn lot help amaze awesome really teach good course nice way new excellent course learn informative fun things wonderful love course experience teacher want course help excellent course amaze course understand
Topic #1: course great great course learn machine machine learn best course great specialization project look helpful best course forward introductory look forward thank andrew start introductory course ng courser cover complete far algorithms knowledge content work ml
Topic #2: good course easy really like understand introduction time program make great follow python start learn basic bite easy understand good course think assignments little use way contect know feel lecture course good explain
Topic #3: usefule recomment course data class highly great recommend program assignments clear science dr use recommend course practical lecture learn understand chuck concepts dr chuck information tool design excellent python intro overview challenge
Topic #4: course thank excellent enjoy learn make really material lecture videos content information like work provide understand think read time quiz excellent course life present help way professor students use question study

that trends are revealed to be related to course content and positivity rather than course rating. Moreover, the top rating of five occupied most of the course ratings taking up 74% of the data with a sample size of 79,173. In other words, the unbalanced output most likely caused lower accuracies in the less represented rating levels along with inherent topics captured by the LDA algorithm.

Future Directions

NLP approaches demonstrate modeling feasibility of Army training performance through textual analysis of AARs. Devices capable of AAR speech capture to be processed for subsequent NLP analysis could provide a capability to improve training outcomes. Overall data architecture and approach as described in this paper can be adapted for military environments and tailored for integration with processes such as the Army Lessons Learned program.

Both the machine-learning model and the CNN model revealed predictability of course rating by analysis of course reviews. This same process can be applied to AAR transcribed data as the input and training performance measures as the output. A separate embedding layer could be created for each of the text fields in terms of (a) what was planned, (b) what went wrong, and (c) how improvements could be made. Doing so will increase variance to the model input and capture distinct patterns linked to differences in training performance. These AARs can be associated with training requirements via systems such as the Army Training Information System that contains metadata surrounding training requirements and skill decay rates.

The predicted output, the course rating, was extremely imbalanced and the review itself consisted of a limited narrative due to limited input data. Therefore, the models all performed relatively poorly on less distinguishable classes. In addition, the models only used one text field as the input. The discussion nature of AARs allows for multiple text inputs to be entered into the model. Application of similar models on AARs would benefit Army training practices allowing the detection of key elements in positive or negative training sessions to be identified. That is, the underlying patterns in the language used when training is successful or goes poorly can be identified. Furthermore, characterizations of AARs linked to training performance may be used to track downward or upward trends in improvements or lack thereof from AARs over time. Extracted lessons from past training can serve as critical guidelines for future improvement. Using this paradigm which stores, aggregates, and analyzes training data, Army leaders can better forecast and understand historical training dynamics, lessons learned, and future planning.

The use of deep learning to yield actionable AAR insight opens the door to myriad possibilities about the iterative process of improvement. Automation tooling and industry-standard methodologies permit the approach outlined in this article to be adapted to a variety of problem domains. Logistics, personnel management, and medicine are examples of other fields of interest with large amounts of free-text records that can be analyzed via novel ML techniques. Many commercial off-the-shelf platforms in use by the Department of Defense's service branches also incorporate such functionality. As the use of ML to analyze free-text data proliferates the industry, applications tailored specifically to military needs will be critical. This work, exploring the specific application of ML to the Army AAR process, can help inform future Army efforts to develop innovative, specialized machine-learning applications to better serve the warfighter.

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Peer Reviewed

A Mixed Methods Analysis of STEM Major Attrition at the U.S. Air Force Academy

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Abstract

Science, technology, engineering, and mathematics (STEM) professionals are indispensable for a robust economy and a strong military in evolving U.S. national security contexts. However, from high school to graduate school, the STEM pipeline loses up to 50% of its potential workforce, particularly in quantitative disciplines. This national trend is observed at the U.S. Air Force Academy (USAFA), where STEM recruitment and STEM major attrition are consistent challenges. Our mixed-methods study examines factors associated with STEM attrition and persistence at the USAFA using two years of academic data from the USAFA's Registrar's Office and a thematic analysis of the narrative responses obtained from surveyed cadets. STEM *Departers* were statistically more likely to have low GPA and SAT Math scores and to have attended a preparatory school before enrolling at USAFA. Also, undecided cadets with higher GPA and SAT scores, secondary majors, and *Scholars* statuses were more likely to major in STEM. Survey data reveals that a lack of information about occupation and labor markets, coursework cognitive load and quantity, and instructor interactions may be linked to STEM attrition. Recommendations to reduce STEM attrition include (a) developing an early-warning, data-driven system to monitor and support STEM-interested freshmen cadets within specific SAT score ranges and whose GPA decrease below a certain threshold; (b) critically reviewing and strengthening the STEM curricula at preparatory schools; (c) providing additional information and peer-led focus groups on the academic expectations of STEM and non-STEM majors; (d) recruiting STEM instructors with pedagogical content knowledge to teach introductory STEM courses; and (e) enhancing the curricula of introductory STEM courses at USAFA with teaching methods supported by research, including project-based and authentic learning, and data-driven modeling.

Graduates from science, technology, engineering, and mathematics (STEM) majors are essential for many professions and for a robust economy (Fayer et al., 2017; Piatkowski, 2020). STEM graduates and a vigorous science and technology workforce have also been identified by the U.S. Department of Defense (National Research Council, 2012a, 2012b, 2014) as essential for a strong military and for an evolving U.S. national security environment that demands greater scope and depth from science and technology. Specifically, the U.S. Air Force has prioritized scientific discovery and has relied on a highly skilled workforce to manage the discovery, development, and integration of STEM to advance its mission (National Research Council, 2010).

The number of college graduates in the United States exceeded 61 million in 2017 and nearly half of employed college graduates earn their highest degree in a science and engineering field (Foley et al., 2020). There is a robust debate among STEM education and policy researchers about the extent to which the output of STEM professionals is adequate for meeting workforce needs or not. Researchers like Camilli and Hira (2019), Carnevale et al. (2014), Hira and Hira (2008), and Piatkowski (2020) have argued that shortages in the STEM workforce are not widespread but dependent on which disciplines are under scrutiny and the methodologies used when mining job posting data. Nevertheless, there seems to be a generalized accord that the United States is not close to meeting the need for the Nation's science and technology talent, and that attrition from the field may be a contributing factor (Apriceno et al., 2020; Belser et al., 2018; Hrabowski & Henderson, 2017; Sithole et al., 2017). STEM shortages seem to be more evident in quantitative disciplines (Duncheon, 2018; National Science Board, 2018).

STEM attrition is defined as enrollment choices that result in students interested in STEM leaving their academic programs by switching majors to non-STEM fields or dropping out of college (Green & Sanderson, 2017; Jelks & Crain, 2020; Shedlosky-Shoemaker & Fautch 2015; Xu, 2018). In the United States, STEM attrition has been reported to be as high as 30-50% (Chen, 2013; National Science Board, 2018).

On the road to becoming STEM professionals, high school graduates struggle at two main points in time: during the transition from high school to college (DeVilbiss, 2014) and when students are completing their science coursework. Students struggle with following the fast pace of science coursework (Seymour & Hunter, 2019), exposure to science lectures that are broadly critiqued for transmitting information without promoting understanding (Petrovic & Pale, 2015; Singh & Phoon, 2021; Wolff et al., 2015; Zhao & Potter, 2016), and applying mathematics and numeracy to solve scientific problems (Bowen et al., 2019; Bressoud, 2015; Brewer et al., 2019; Gottfried, 2015; Hilgoe et al, 2016; Jacobs & Pretorius, 2016). Unfortunately, STEM attrition is found to be more prevalent among college students who are minorities, first-generation, or those coming from low-income backgrounds (Chen, 2015).

Students leave collegiate STEM programs for reasons other than grades (Chen, 2013). The literature also considers the importance of attitudinal factors associated with STEM attrition, like motivation and beliefs about their future professional occupations (Cabell, 2021; Morgan et al., 2013), student self-regulation habits (Park et al., 2019), career value-expectancy (Appianing & Van Eck, 2018), and STEM self-efficacy (Cohen & Kelly, 2020).

Maj. Daniel O'Keefe graduated from the United States Air Force Academy in physics and mathematics, and then earned his MS in physics from Purdue University and PhD in applied physics from the Air Force Institute of Technology. He has served as a physicist in the U.S. Air Force since 2010, with assignments at the Air Force Research Lab Weapons Directorate and the Air Force Nuclear Weapons Center. He is currently an assistant professor in the Department of Physics and Meteorology at the United States Air Force Academy.

Jorge A. Valentine-Rodríguez currently works as the STEM and workforce director for the Puerto Rico Science, Technology and Research Trust, a nonprofit organization tasked to foster innovation and research in the fields of science, technology, and socioeconomic development on the island. He holds a BA in business administration from the University of Puerto Rico and an MA in humanities from Sagrado Corazón University in San Juan. As part of his leadership duties at the Science Trust, Valentine develops and leads research projects in general STEM Education as well as STEM career selection, persistence, and attrition among university freshmen. In 2021 he completed his first year as an Air Force Research Lab Summer Faculty Fellow with the Center for Physics Education Research, Department of Physics and Meteorology, United States Air Force Academy, Colorado.

In the case of the United States Air Force Academy (USAFA), Dwyer et al. (2020) reports factors associated with cadets completing their bachelor's degree in STEM compared with data from a survey of cadets' interest in STEM majors four years prior. The survey, offered by the Basic Sciences Division, was completed by cadets the summer before their freshman year. According to the survey, 56.5% of cadets were STEM-interested and 30.0% were non-STEM-interested (the rest were undecided). Four years later, 36.4% of the cadets who were STEM-interested switched majors and graduated with a non-STEM major. In contrast, only 6.3% of the non-STEM-interested switched majors and graduated with a STEM major. Most cadets changed their intention to major in STEM before declaring a major (González-Espada et al., 2020a, 2020b, 2021; O'Keefe et al., 2021).

Purpose and Research Questions

The researchers were interested in improving the graduation rates of STEM majors at USAFA by analyzing the factors associated with cadets becoming STEM *Departers* or STEM and non-STEM *Persisters*. The researchers used two academic years' worth of data (AY 2019-20 and AY 2020-21) and a qualitative analysis of data from a survey designed to explore attitudinal factors associated with STEM attrition. Table 1 summarizes which USAFA majors were classified as STEM and non-STEM.

The research questions for the study were:

- Is there a significant difference in the demographic and academic factors for STEM *Departers* and STEM *Persisters* in the AYs 2019-20 and 2020-21?
- Which data-based models can best identify cadets at risk of becoming STEM *Departers*?
- According to cadets, what practices can USAFA implement to improve recruitment into STEM or prevent attrition from STEM majors?

Maj. Lachlan Belcher graduated from the United States Air Force Academy (USAFA) in physics and mathematics (2003) and then earned his MS in physics from the Air Force Institute of Technology (2005). He then served as the system survivability program manager for intercontinental ballistic missiles at Hill Air Force Base, Utah. Belcher returned to the Air Force Institute of Technology (2007) to earn his PhD in physics. Afterward, Belcher was a deputy branch chief and lead test director of the Starfire Optical Range at Kirtland Air Force Base, New Mexico (2011). In 2014, Belcher was reassigned to the National Reconnaissance Office in Chantilly, Virginia, as part of the Imagery Intelligence directorate and subsequently the Survivability Assurance Office. In 2018, Belcher was selected as an assistant professor at USAFA and later as the director of the Center for Physics Education Research. In the summer of 2021, Belcher joined the physics faculty at Brazil's Instituto Tecnológico de Aeronáutica as a military exchange officer.

These research questions were selected because even though military higher education institutions differ from traditional public/private universities in that their curricula focus on key components of military careers such as Military and Strategic Studies and physical training (Kennedy, 2017), the literature associates STEM attrition with both quantifiable aspects of academic life and attitudinal factors that apply to both military and civilian institutions. By exploring answers to these research questions, the body of research-based knowledge on STEM pathway persistence will grow, which could result in improved interventions to address STEM attrition.

Methodology

The quantitative portion of the study relied on data pulls from the USAFA Registrar's Office: eight monthly pulls from AY 2019-2020 and 10 monthly pulls from AY 2020-2021. Independent variables collected included cadet gender, race, class rank (based on graduation year), presence of a secondary major, number of declared minors, status as preparatory school graduate, participation in the *Scholars Program*, GPA at the end of the academic year, SAT Math (SAT-M) scores, and SAT Reading and Writing (SAT-RW) scores.[1] The dependent variable was major status, which was classified as either STEM *Arrivers* (those cadets who switched from a non-STEM major to a STEM major), STEM *Departers* (those cadets who switched

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Lt. Col. David Meier graduated with a BS in physics from the United States Air Force Academy in 1996 and served as an operational C-130 pilot for twelve years. He returned to physics and earned his MS in applied physics in 2010 and PhD in applied physics in 2015, both from the Air Force Institute of Technology. He is currently an assistant professor of physics and the director of core programs for the Department of Physics and Meteorology at the United States Air Force Academy. His research interests include atmospheric effects on laser propagation, curriculum development, and physics education research.

Table 1
USAFA Majors Classified as STEM or non-STEM

Non-STEM Majors	STEM Majors
Bachelor of Science	Basic Science
Behavioral Sciences (General, Human Factors, Leadership)	Biochemistry
Economics	Biology
Economics	Chemistry (General, Materials)
Foreign Area Studies (General, Geography, History, Military & Strategic Studies, Political Science)	Computer and Network Security
General Studies (Humanities, Social Sciences)	Computer Science (Cyber Warfare Option, General)
Geospatial Science	Cyber Science
History (American, General, International, Military)	Data Science
Humanities	Engineering (Aeronautical, Astronautical, Chemical, Civil, Computer, Electrical, Environmental, General, Mechanical, Systems, Systems Management)
Legal Studies	General Studies (Basic Sciences, Engineering)
Military & Strategic Studies	Mathematics (Applied, General)
Philosophy	Meteorology
Political Science	Operations Research
Social Sciences	Physics
	Space Operations

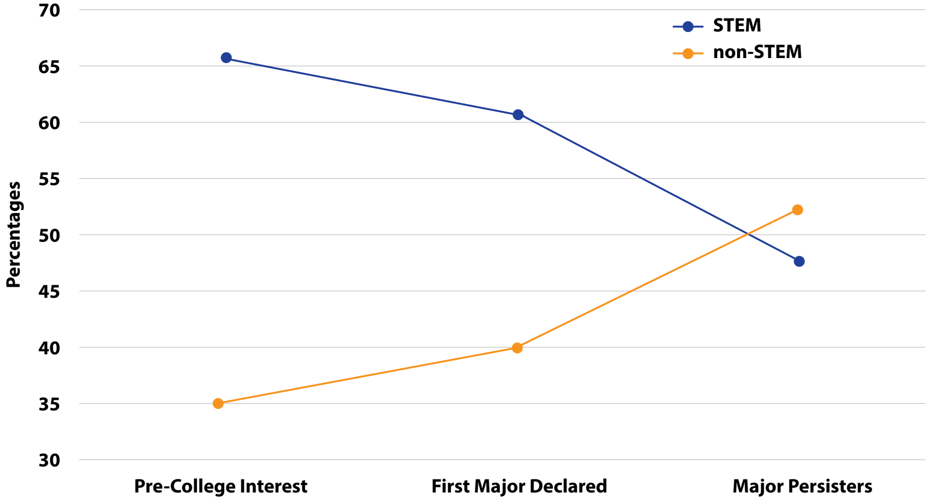
From "Course of Instruction 2021–2022," by United States Air Force Academy, 2021.

from a STEM major to a non-STEM major), STEM *Persisters* (those cadets who kept the same STEM major), non-STEM *Persisters* (those cadets who kept the same non-STEM major), cadets who changed from a STEM major to a different STEM major (classified together with STEM *Persisters*), cadets who changed from a non-STEM major to a different non-STEM major (classified together with non-STEM *Persisters*), undecided cadets who declared a STEM major, and undecided cadets who declared a non-STEM major. Because many cadets showed up in the data set for both AYs, duplicates were removed.

The data analyses consisted of descriptive statistics for each of the variables and inferential statistics comparing independent and dependent variables one at a time. In addition, a binary logistic regression model was used when appropriate (Hosmer et al., 2013; Legg et al., 2001; Osborne, 2015) to obtain the best model of which factors were most closely associated with the dependent variable. Because of the exploratory nature of this test, minimum statistical significance was

Figure

Percentage of Cadets and Their Interest in STEM and non-STEM Majors at Three Points During Their Time at USAFA



assigned a probability (p) value of less than 0.05 to balance the risks of Types I and II errors.

The qualitative portion of the study relied on a short survey. The sample consisted of 44 USAFA cadets who voluntarily answered the prompt: “In the near future, the Air Force may consider possible alternatives to increase the number of cadets who graduate with undergraduate degrees in Basic Sciences/Engineering. What three recommendations should the Academy implement to attract undecided cadets to declare a major in Basic Sciences/Engineering?” A survey methodology was selected because it provides flexibility in conducting the study, uses narrative material in a research design, and integrates tools to contextualize the views of a particular group rather than generalize across a whole population (Check & Schutt, 2012; Creswell, 2012; Swayne & Dodds, 2011).

Utilizing Quirkos, a qualitative data visualization software, responses were analyzed using the phases of Thematic Analysis (Boyatzis, 1998; Braun & Clarke, 2006; Creswell & Tashakkori, 2007; King, 2004; Nowell et al., 2017; Saldaña, 2021). The four phases included (a) *familiarization* with the data, completed through repeated reading of the data and actively searching for meaning and patterns among emerging noticeable traits on words and phrases collected; (b) *initial code generation*, to begin identifying core recommendations; (c) *sorting and collating relevant data and searching for themes*, which capture and unify the nature or basis of the experience into a meaningful whole (Desantis & Ugarriza, 2000); and (d) *review of themes*, where the major themes were clarified, reorganized, consolidated, and named to immediately give the reader a sense of what the themes were about.

Results

Descriptive Statistics for the Independent Variables

The data set comprised of 5,070 cadets split between 3,627 (71.5%) male cadets and 1,443 (28.5%) female cadets. The sample included 3,280 (64.7%) Caucasian cadets and 1,634 (32.2%) cadets from underrepresented minorities. Race data were not available for 156 (3.1%) of the cadets. A total of 973 cadets (19.2%) attended a preparatory school and 332 cadets (6.5%) were classified as *Scholars*.

Cadets were classified as freshmen who declared a major (614, 12.1%), sophomores (1,321, 26.1%), juniors (1,088, 21.5%), seniors (1,060, 20.9%), and seniors who graduated in May 2020 (986, 19.4%). Of the freshmen cadets, 464 cadets did not declare a major at the time of this study. Most cadets, 3,544 (97.0%), declared a single major, with 108 cadets (3.0%) declaring a secondary major. For academic minors, 2,827 cadets (77.4%) did not have one, 763 cadets (20.9%) declared one minor, and 62 cadets (1.7%) declared two minors.

The average GPA in the sample was 3.07, with a standard deviation of 0.57 points. The skewness and kurtosis values did not exceed ± 1.0, which means that GPA can be approximated as a normally distributed variable. The SAT-RW scores for cadets averaged 670 points and had a standard deviation of 62.3 points. SAT-M scores were higher, with an average of 683 points and a standard deviation of 70.2 points. Like GPA, the SAT skewness and kurtosis values did not exceed ± 1.0.

Descriptive Statistics for the Dependent Variables

Of the cadet sample, 3,297 cadets kept the same major in both AYs, with totals similarly split among STEM and non-STEM disciplines; 1,553 cadets (47.1%) declared a STEM major, and 1,744 cadets (52.9%) declared a non-STEM major. 215 cadets changed from one major to another within the same discipline; 119 cadets (55.3%) switched within STEM majors and 96 cadets (44.7%) switched within non-STEM majors. For the 1,420 undecided cadets who declared a major, 857 (60.4%) of them chose a STEM major, and the rest, 563 (39.6%), chose a non-STEM major.

A total of 137 cadets were STEM *Arrivers* or *Departers*. While 121 cadets (88.3%) switched from STEM to non-STEM, only 16 cadets (11.7%) switched in the other

Table 2

Number of Cadets as a Function of the Categorical Variables of Interest

Variable	Descriptor	Major Code* and Number of Cadets								Total
		1	2	3	4	5	6	7	8	
Gender	Male	10	88	76	63	1,166	1,238	608	377	3,626
	Female	6	33	43	33	387	506	249	186	1,443
Race	Causasian	10	75	71	55	1,051	1,088	560	369	3,279
	Minority	5	42	46	39	455	579	280	188	1,634
Attended Prep School	No	13	87	96	67	1,372	1,310	742	409	4,096
	Yes	3	34	23	29	181	434	115	154	973
Scholars Status	No	12	118	111	88	1,378	1,691	797	542	4,737
	Yes	4	3	8	8	175	53	60	21	332
Class Rank/ Year	Freshman	1	2	0	0	0	0	431	180	614
	Sophomores	6	68	52	23	253	120	423	376	1,321
	Juniors	9	41	54	56	445	474	3	6	1,088
	Seniors	0	10	9	17	449	573	0	0	1,058
	2020 Grads	0	0	4	0	406	573	0	0	986
Secondary Major	No	16	120	117	92	1,469	1,705	827	558	4,904
	Yes	0	1	2	4	84	39	30	5	165
Number of Minors	None	14	93	97	60	1,137	1,198	761	497	3,857
	One	2	25	22	34	401	497	89	56	1,127
	Two	0	3	0	2	15	49	7	10	86

Note. Major codes are 1 for STEM *Arrivers*, 2 for STEM *Departers*, 3 for cadets who changed from a STEM major to a different STEM major, 4 for cadets who changed from a non-STEM major to a different non-STEM major, 5 for STEM *Persisters*, 6 for non-STEM *Persisters*, 7 for undecided cadets who declared a STEM major, and 8 for undecided cadets who declared a non-STEM major.

direction, an eight-to one ratio. The Figure compares the percentage of cadets' choice for STEM and non-STEM majors before starting their first semester, when a major was declared, and as upperclassmen.

Table 2 summarizes the number of cadets within each categorical independent variable, classified by STEM and non-STEM major switching, if any. Table 3 summarizes the average GPA and SAT scores, along with their standard deviation, classified by STEM and non-STEM major switching, if any.

Table 3
Descriptive Statistics for the Quantitative Variables of Interest

Variable	Major Code* and Number of Cadets							
	1	2	3	4	5	6	7	8
GPA	3.23	2.74	3.08	2.85	3.25	2.93	3.25	2.79
	0.52	0.49	0.48	0.51	0.44	0.47	0.52	0.54
SAT-RW	665.6	657.2	662.8	656.7	678.6	653.9	681.0	653.8
	68.3	54.1	66.2	71.4	58.2	60.0	59.1	63.6
SAT-M	683.1	668.7	693.0	648.2	702.1	652.0	704.5	650.1
	68.5	63.8	77.6	72.4	62.4	62.4	63.7	66.9

Note. Major codes are 1 for STEM *Arrivers*, 2 for STEM *Departers*, 3 for cadets who changed from a STEM major to a different STEM major, 4 for cadets who changed from a non-STEM major to a different non-STEM major, 5 for STEM *Persisters*, 6 for non-STEM *Persisters*, 7 for undecided cadets who declared a STEM major, and 8 for undecided cadets who declared a non-STEM major.

Inferential Analysis of STEM Departers and Persisters

Categorical Data. The sample size consisted of 1,672 STEM *Persisters* and 121 STEM *Departers*. Due to the categorical nature of the data, a Chi-square analysis was conducted (using raw data, not percentages) and reported in Table 4. Subcategories with five or fewer individuals were noted so that any significant relationships are interpreted carefully.

It was found that gender, race, and whether a cadet has a minor were not statistically associated with STEM attrition. Cadets who graduated from a prep school were significantly more likely to become STEM *Departers*. Cadets classified as *Scholars* were significantly less likely to become STEM *Departers*. Having a secondary major seems to be associated with persisting as a STEM major; however, there were not enough cadets for a definitive test.

Quantitative Data. Due to the level of measurement of GPA and SAT scores, t-test statistics comparing their averages were calculated and reported in Table 5. Levene tests showed statistically similar variances, so the reported t-statistics assume homoscedasticity. The statistical analysis demonstrated that STEM *Departers* were more likely to have lower GPA and SAT scores compared with STEM *Persisters*. A Pearson correlation test showed significant correlations between GPA and SAT-RW ($r = 0.438$, $p < 0.001$), GPA and SAT-M ($r = 0.500$, $p < 0.001$), and SAT-M and SAT-RW ($r = 0.612$, $p < 0.001$).

Table 4
Statistical Comparison of Categorical Variables for STEM Persisters *and* Departers

Variable	Descriptor	STEM *Departers*	STEM *Persisters*	Total	X^2	*df*	*p*
Gender	Male	88 6.6%	1,242 93.4%	1,330	0.142	1	0.706
	Female	33 7.1%	430 92.9%	463			
Race	Causasian	75 6.3%	1,122 93.7%	1,197	1.285	1	0.257
	Minority	42 7.7%	501 92.3%	543			
Attended Prep School	No	87 5.6%	1,468 94.4%	1,555	24.774	1	< 0.001
	Yes	34 14.3%	204 85.7%	238			
Scholars Status	No	118 7.3%	1,489 92.7%	1,607	8.697	1	0.003
	Yes	3 1.6%	183 98.4%	186			
Secondary Major	No	120 7.0%	1,586 93.0%	1,706	4.555	1	0.033
	Yes	1 1.1%	86 98.9%	87			
Number of Minors	None	93 7.0%	1,234 93.0%	1,327	0.547	1	0.459
	One or two	28 6.0%	438 94.0%	466			

Binary Logistic Regression (BLR) Model. The model included attendance to prep school, *Scholars* status, GPA, and SAT-M scores. The reason why SAT-RW was not included in the model is because BLR is susceptible to multicollinearity (Evans, 1996). The best BLR model, which explained 17.1% of the variance in the data (per the Nagelkerke pseudo R^2 coefficient), revealed that the only predictor of cadets becoming STEM *Departers* was GPA, which is consistent with a previous significant *t*-test.

The other variables were loaded into the BLR model in the order shown in Table 6; however, these additional variables did not significantly increase the explained variance.

Table 5

Statistical Comparison of Quantitative Variables for STEM Persisters *and* Departers

Variable	Average ± Standard Deviation Sample Size		t	df	p
	STEM *Departers*	STEM *Persisters*			
GPA	2.74 ± 0.49 121	3.23 ± 0.45 1,671	-11.58	1,790	< 0.001
SAT-RW	657.2 ± 54.1 121	677.5 ± 58.9 1,658	-3.67	1,777	< 0.001
SAT-M	668.7 ± 63.8 121	701.5 ± 63.6 1,658	-5.46	1,777	< 0.001

Table 6

BLR Results for STEM Departers *and* Persisters

Best Model	Wald	e^B	p	*Nagelkerke Pseudo* R^2
GPA	104.9	9.87	< 0.001	0.171
Prep School	0.512	-	0.474	
Scholars Status	0.044	-	0.833	
SAT-M	0.528	-	0.467	

STEM Arrivers. The sample consisted of 1,840 non-STEM *Persisters* (who either remained in their original non-STEM major or switched between non-STEM majors) and 16 STEM *Arrivers*. The only categorical variables that appeared to be associated with cadets leaving non-STEM majors for STEM majors was *Scholars* status. For quantitative data, t-test statistics demonstrated that STEM *Arrivers* are more likely to have higher GPA ($t = 2.54$, $df = 1{,}854$, $p = 0.011$) and SAT-RW scores ($t = 2.32$, $df = 15.22$, $p = 0.034$) compared with non-STEM *Persisters*. However, the small sample size of STEM *Arrivers* limited the conclusiveness of these findings.

Inferential Analyses of Undecided Cadets Who Declared a Major Categorical Data. The sample size consisted of 857 (60.4%) undecided cadets who declared a STEM major and 563 (39.6%) undecided cadets who declared a non-STEM major. Using raw data (not percentages), Chi-square analyses were calculated and reported in Table 7. None of the analyses included five or fewer individuals.

Cadets who were in the *Scholars Program* and who declared a secondary major were statistically more likely to declare a STEM major. Cadets who attended a preparatory school were statistically more likely to declare a non-STEM major.

Table 7
Statistical Comparison of Categorical Variables for Undecided Cadets Selecting a Major

Variable	Descriptor	Declared STEM Majors	Declared non-STEM Majors	Total	X^2	*df*	*p*
Gender	Male	608 61.7%	377 38.3%	985	2.536	1	0.111
	Female	249 57.2%	186 42.8%	435			
Race	Causasian	560 60.3%	369 39.7%	929	0.026	1	0.871
	Minority	280 59.8%	188 40.2%	468			
Attended Prep School	No	742 64.5%	409 35.5%	1,151	42.967	1	< 0.001
	Yes	115 42.7%	154 57.2%	269			
***Scholars* Status**	No	797 59.5%	409 35.5%	1,339	6.759	1	0.009
	Yes	60 74.1%	21 25.9%	81			
Secondary Major	No	827 59.7%	558 40.3%	1,385	9.646	1	0.002
	Yes	30 85.7%	5 14.3%	35			
Number of Minors	None	761 60.5%	497 39.5%	1,258	2.687	2	0.261
	One or two	89 61.4%	56 38.6%	145			

Quantitative Data. *T*-test statistics comparing the average GPA and SAT scores of undecided cadets who declared STEM and non-STEM majors were calculated and reported in Table 8. Undecided cadets who declared a STEM major had significantly higher GPA and SAT scores, as shown in Table 9.

BLR Model. This model included prep school attendance, *Scholars* status, secondary major, GPA, and SAT-M scores. Given that SAT-RW and SAT-M scores are highly correlated (r = 0.612, p < 0.001), only SAT-M was used to avoid multicollinearity. The best BLR model, which explained 25.0% of the variance in the data, revealed that the strongest predictor of cadets declaring a STEM major was GPA, followed by SAT-M scores, and *Scholars* status.

Table 8

Statistical Comparison of Quantitative Variables for Undecided Cadets Selecting a Major

Variable	Average ± Standard Deviation Sample Size		t	df	p
	Declared STEM Majors	Declared non-STEM Majors			
GPA	3.25 ± 0.52 857	2.79 ± 0.54 563	15.70	1,418	< 0.001
SAT-RW	681.0 ± 59.1 857	653.8 ± 63.6 563	8.24	1,418	< 0.001
SAT-M	704.5 ± 63.7 857	650.1 ± 66.9 563	15.44	1,418	< 0.001

Table 9

BLR Results for Undecided Cadets who Declared a Major

Best Model	Wald	e^B	p	*Nagelkerke Pseudo* R^2
GPA	71.62	0.326	< 0.001	0.196
SAT-M	61.329	0.992	< 0.001	0.247
Scholars Status	5.024	1.893	0.025	0.250
Prep School	-	-	0.749	
Secondary Major	-	-	0.087	

Inferential Analyses of GPA and SAT Scores by Major

Since SAT scores and cadet interest in STEM disciplines are known to USAFA before cadets start their first semester, statistically comparing these scores by major status while keeping track of GPA could provide an early predictor of potential STEM *Departers*. A Levene statistic revealed that the between-group variances by major status were not similar, likely caused by the wide variation in sample size between groups, so a Kruskal-Wallis (nonparametric) comparison was more appropriate.

The Kruskal-Wallis tests showed that the GPA of STEM *Departers* is the lowest of the group, a GPA like that of non-STEM cadets, those who were undecided, and those who switched within non-STEM majors. In contrast, the SAT scores of STEM *Departers* are located near the midpoint of the distribution. Most SAT-RW scores are statistically similar, except for the significantly higher scores of STEM *Persisters* and undecided cadets who declared STEM majors. For SAT-M scores, only the

Table 10
Theme and Code Summary for Qualitative Cadet Responses

Themes	Description	Total Codes
Occupation and Job Markets	Refers to occupational value expectancy and future job opportunities once USAF/USSF commitments are fulfilled. Also contains coded information regarding internships and civilian opportunities and job markets.	19
Coursework Difficulty	Perceived notions of challenging or difficult course content that requires effort or scaffolding not accounted for before beginning the course.	16
Coursework Quantity	Refers to the content amount and pacing required to complete the course.	15
Instructors	Refers to recommendations regarding instructor dynamics, perceptions of teaching styles, instructor support during learning, and perceived depth of knowledge.	11
Other STEM Informal Learning Opportunities	Informal learning opportunities include field trips, museums, guest speakers, and other activities where knowledge transfer occurs outside USAFA.	3
Quality of Life	Narrative referring to perceived levels of stress or limited time to balance academics with non-academic, including the required USAFA physical and military leadership training.	2
Textbook Fees	High cost of textbooks required for STEM courses.	1
Diversity and Inclusion	Recommendation regarding broad communications of activities within USAFA where women and minorities are represented.	1
Total number of codes		68

scores of STEM *Arrivers* are statistically like that of STEM *Departers*. These results suggest that the mathematical and oral/written communication proficiency of STEM *Departers* before starting their freshmen year are adequate for cadets to thrive, at least in some STEM majors.

Qualitative Analysis of Survey Responses

Four major themes were identified from the qualitative responses shared by 44 cadets: (a) *occupation and job market*; how cadets perceived their future professional opportunities and how the general job prospects outside USAFA linked with the current majors offered; (b) *coursework difficulty*, recommendations and comments that pertained to the sense of efficacy and difficulty of the STEM major courses; (c) *coursework quantity*, recommendations about reducing the number of topics, tasks, and activities that need to be completed in each course; and (d) *instructors*, comments and recommendations to USAFA regarding faculty interaction and quality.

Table 10 listed the top 10 themes that emerged from the data and how many cadets provided them. A single cadet's response could code under multiple themes.

Occupation and Job Market. Nineteen of the surveyed cadets indicated that occupation and job market considerations, if discussed broadly during the undeclared period at the academy, could attract undecided cadets to declare a major in basic sciences and engineering. These statements reflect limitations either on access to such information or a lack of active search for the information on behalf of the cadets. Regarding declaring and retaining STEM majors at the academy, a cadet commented: "Show how they are applicable outside USAFA," while another stated that it was important to "tell people the job outcomes of those majors." Other recommendations pointed to a keen interest among cadets to have full disclosures on the necessary work, time, and effort required for STEM courses, arguing that "before [cadets] come [to USAFA], that's the time to tell them that it's a STEM school." This notion aligns with the manifested need for information on what majors "do" outside USAFA and what the occupational outlooks are for each major. This same recommendation is repeated under the coursework quantity theme, as they align in intention and scope.

Coursework Difficulty. Sixteen cadets reported on the perceived high level of difficulty throughout STEM major coursework. One participant expressed it in direct terms by requesting an "easier workload for engineering classes" and to make "engineering more approachable for those without experience." These statements denote cadets without previous engineering experience find the coursework at the academy challenging. This is an indication of gaps in knowledge or skills or that cadets lack the necessary scaffolding for engineering coursework before entering USAFA. Another interpretation for cadet comments on coursework difficulty might be related to what Bar et al. (2009) reported on the scholarly traits of students who move to courses with less "difficulty" at traditional universities; they explain that students gravitate toward leniently graded courses to maintain stronger GPAs. This trend may be further incentivized at USAFA, since GPA is heavily weighted in selection of cadets' future occupational careers (i.e., cadets with higher GPAs are more likely to get their career fields of choice, especially if they are interested in becoming pilots).

Coursework Quantity. Fifteen cadets manifested feeling "[burnt] out," "exhausted," and had a "decrease in quality of life." For instance, two cadets suggested "decrease the workload on students who choose STEM majors" and for instructors to "go at a slower pace covering course content." It is here the concept of course quantity links with the idea of a large amount of content versus the pace at which the course is covered. Identification of such notions is significant as burnout fully mediates the relationship between effort-reward imbalance and withdrawal intentions for both first year and subsequent-year students (Williams et al., 2018).

Instructors. Eleven cadets reported low satisfaction with their interactions with course instructors, stating that "STEM major teachers need to act like they care more about cadets" and that USAFA should "allow better teachers to teach core classes instead of the worst ones in the department." Cadet recommendations included revising the hiring requirements for faculty, "[getting] better teachers in STEM courses," encouraging facilitators to become more engaged with students in the courses, and improving the quality of instructors, in terms of content delivery and providing student support.

Discussion

The quantitative data indicated that STEM *Departers* were more likely to have relatively low GPA and SAT-M scores, more likely to come from a preparatory school, and less likely to be in the *Scholars Program*, compared with STEM *Persisters*. Undecided cadets who later declared a STEM major were more likely to be in the *Scholars* program, to declare a secondary major, and to have higher GPA and SAT scores while less likely to have attended a preparatory school. When comparing the distribution of SAT scores, STEM *Departers* seemed to be at a critical midpoint in the score distribution and may go either way in terms of career selection depending on their freshmen coursework. The GPA data suggested that, as underclassmen, cadets probably struggled with the high school to college transition, attitudinal factors like motivation and self-efficacy (Aulck et al., 2017; Chen, 2013; Cohen & Kelly, 2020; Park et al., 2019). Cadets also struggled with introductory science classes such as physics and chemistry. Along with calculus, these courses were previously identified as gateway classes at USAFA (Dwyer et al., 2020). As their GPAs decreased, many undecided cadets who were interested in STEM declared non-STEM majors, while others who had declared STEM majors quickly switched out of them as they encountered academic difficulties.

The fact that the demographics and academics BLR model could explain no more than 20-25% of the data variance implies that nonacademic and attitudinal factors impact STEM attrition. Cadet recommendations for additional information about employment options for different majors may indicate a low awareness of occupational value expectancy (Appianing & Van Eck, 2018) regarding careers within and outside military ecosystems. The limitations of the BLR model could also be due to low levels of academic self-regulation (Park et al., 2019).

Within the teaching community, the term "course difficulty" is generally accepted to communicate the learning content complexity of a course. This complexity is often attributed to the levels of necessary scaffolding to support students as they learn ever more complex topics, helping them achieve the expected learning outcomes, and employing the appropriate pedagogies to teach the course (Andres, 2017). Since GPA comprises nearly two-thirds of the model used to determine which Air Force jobs cadets will have upon graduation (e.g., entrance selection for pilot training programs), some cadets may depart STEM majors simply to choose an easier major and improve their grades. Additionally, cadets might likely be reacting to factors like teaching style, strategies, and tactics, as well as each course's learning content complexity (Bailey et al., 2016).

Recommendations

Based on the mixed-methods analyses, several suggestions for improvement can be put forth. One recommendation to identify opportunities to prevent STEM departures and incentivize STEM arrivals is the development of a data-driven algorithm that uses monthly data pulls from the registrar's office to monitor freshmen cadets and immediately identify those at risk of becoming STEM *Departers* and those who could be recruited into STEM majors. Cadets who identify themselves as STEM-interested in the basic sciences survey offered before first semester classes start and who have SAT scores above a certain threshold can go into a database. As the first semester progresses, any cadet on the list whose GPA drops below a certain threshold could be flagged for an interview with a STEM academic success specialist. The goal of this specialist would be to accurately isolate the root causes of the cadet's academic struggles and help him or her address these causes. A potential obstacle for implementing this recommendation might be resourcing of the academy-wide office or academic departments to lead and manage this effort.

Prep school attendance consistently arose as a factor associated with STEM attrition. It is recommended that USAFA critically examine the preparatory school's science, mathematics, and engineering curriculum and enhance it as needed. A good starting point may be to consider implementing authentic science experiences, model development, and data-driven modeling, praised by many in the field for their connection with best practices in STEM education (Hallström & Schönborn, 2019).

Cadets' academic performance in STEM courses could improve if USAFA hires or provides faculty with pedagogical preparation to instruct introductory STEM courses. The literature documents that introductory courses should be taught by experienced instructors who are better equipped to avoid the teaching methodology pitfalls that many less experienced instructors have (Burroughs et al., 2019; Podolsky et al., 2019). Military faculty typically teach for three to four years, so they may not have enough time to develop experience and pedagogical content knowledge.

Possible options may be to hire experienced civilian faculty members with a background in STEM pedagogies for introductory STEM courses or to provide additional institutional support to military faculty through quality professional development. One option could be sending military faculty to complete a one-year graduate certificate or master's degree in STEM Curriculum and Instruction through a collaboration with the University of Colorado at Colorado Springs. This university already provides a master's degree in Counseling and Leadership for the Air Officer Commanding Leadership Development Program at USAFA. Another option could be arranging pedagogical training through military organizations like the Center for Educational Innovation (Air Force) and the Faculty Development and Recognition Program (Army). They can provide STEM-specific faculty development opportunities, build STEM-centered communities of practice (Gehrke & Kezar, 2019; Ma et al., 2019; Stark & Smith, 2016), and assist in building a pipeline that can return high-performing instructors to training and education assignments more than once in a career.

A final recommendation, which would increase cadet knowledge about both STEM and non-STEM coursework difficulty, quantity, and time and effort commitments, is to create additional recruitment information sessions. In these carefully planned sessions, new cadets meet with senior cadets to discuss experiences and challenges, with a focus on the opportunities open to them because of their chosen major.

Conclusion

The U.S. Department of Defense considers a well-qualified STEM workforce as essential for a robust military, and USAFA is uniquely positioned to increase the quality of graduates in STEM careers. The purpose of this study was to use a mixed-methods approach to examine academic, demographic, and attitudinal factors associated with USAFA cadets becoming STEM *Departers*. The first research question asked to what extent there was a significant difference in the demographic and academic factors for STEM *Departers* and STEM *Persisters*. It was found that cadets who attended prep school, who were not classified as *Scholars*, who had low GPAs, and who had low SAT-M or low SAT-RW scores were more likely to switch out of STEM majors.

The second research question asked which data-based models could best identify cadets at risk of becoming STEM *Departers*. From the binary logistic regression model of STEM *Departers*, GPA emerged as the strongest factor associated with cadets leaving or arriving at STEM majors.

The third research question asked cadets to identify practices USAFA can implement to prevent attrition from STEM majors. Thematic analysis provided valuable insight into cadet attitudinal perceptions, uncovering recommendations within four main areas: occupation and job market, coursework difficulty, coursework quantity, and instructors. The identification of these four themes was consistent with the literature regarding STEM attrition and retention and could lead USAFA to consider attitudinal factors to fine-tune predictive or early warning systems for retaining STEM-interested cadets.

In terms of future research, classifying majors dichotomously into broad categories of STEM and non-STEM may not be capturing the nuances of each major and their role in STEM attrition. A possible alternative could be to examine attrition for individual STEM majors to account for their academic rigor and quantitative load. A likely hypothesis is that attrition is more prevalent in quantitative STEM majors (e.g., chemistry, engineering, mathematics, and physics), compared to majors in the life sciences. Future studies could also examine the role of course design in STEM classes, particularly those at the introductory level. Instructors with good instructional skills may not be able to maximize their cadets' academic performance if the course's design is inconsistent with the latest research-based practices in STEM teaching and learning.

According to the National Academies of Sciences, Engineering, and Medicine (2015), the Air Force requires the products of basic STEM research, which are critical to future success, and the Air Force's capabilities in these disciplines must expand at an accelerating rate to keep pace with increased mission complexities and the access of relevant technologies to potential adversaries. It is critical to recognize the problem of STEM attrition at military higher education institutions, and as a national security imperative, the Air Force should invest resources to prioritize its reduction among cadets.

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Note

1. The Scholars Program at USAFA helps academically talented cadets reach their full potential by offering special core course sections that deepen and broaden Scholars' intellectual development and opportunities for completing a senior thesis or capstone project in the cadet's chosen major.

The Impact of Military Occupational Specialty Training on the Trait Development of Marines

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Abstract

The U.S. Marine Corps expends extensive effort to instill its core values into marines. The process of transforming civilians into marines begins with recruiting select members and continues with entry-level training, commonly referred to as boot camp. However, the Marine Corps does not expect marines to leave boot camp with fully formed identities and values orientations. These characteristics, which are also classified as traits and professional military attributes, develop with sustained effort over time. Drawing on these characteristics, this mixed-method study measured the four dependent variables of honor, courage, critical thinking, and marine identity, to determine whether experiences at military occupational specialty (MOS) schools sustain the basic-level marine transformation process begun during boot camp. A sample of 231 U.S. marines were interviewed across four MOS schools. While research has examined the relationships between values and attitudes, behavior, and decision-making, little is known about when and how values influence critical thinking; the complex nature of value structures has been neglected. The research questions were measured using quantitative pre- and posttests. In addition, the posttest consisted of six qualitative, open-ended questions, contributing to data confirmation and deeper insights around the constructs. The quantitative results revealed an increase in both honor and marine identity scale scores between pretest and posttest for all marine students. The critical thinking and courage scales were unchanged by the experience at MOS schools. These results suggest that the MOS schools sustain, and in some instances, enhance transformation to marines after boot camp and also provide further insight into the within-person stability of these scales, both over time and in context.

The U.S. Marine Corps expends extensive effort to instill its core values into marines. The process of transforming civilians into marines begins with recruiting select members and continues with entry-level training, commonly referred to as boot camp. However, the Marine Corps does not expect marines to leave boot camp with fully formed identities and values orientations. These characteristics, which are also classified as traits and professional military attributes, develop with sustained effort over time.

Becker (2013) provides empirical evidence that informs and deepens our understanding of the effectiveness of values inculcation and identification that occurs during Marine Corps boot camp and the Crucible. The Crucible is the fifty-four-hour boot camp capstone event consisting of forty miles of forced marches, and thirty-two stations that test physical toughness and mental agility. His study measures the effects of the Crucible on the four variables of honor, courage, critical thinking, and identity through the lens of the socialization process occurring during boot camp. His study reveals measurable and statistically significant gains in the recruits' values orientations and identities, attributable to the recruit training socialization process from entry processing to completion.

However, the Marine Corps recognizes that marines do not emerge from boot camp with fully formed core values and marine identities. Established or inherently desirable states can atrophy into less-than-desirable states. Sustaining transformations requires investments of energy and engaged leadership; when exposed to undesirable external influences, many marines' developments naturally decline or erode (Boyatzis, 2006). As continued formation and sustainment efforts are required, the Marine Corps will continue to ask if transformation is sustained.

This article seeks to determine if and how the experience of the four military occupational specialty (MOS) schools offered at the Marine Corps detachment on Fort Leonard Wood, Missouri, reinforces and sustains the basic-level marine transformation process. A mixed methods study was used to measure four dependent variables: honor, courage, critical thinking, and marine identity. This article provides guidance for strategies using experiential forms of adult development, training, and education, to aid senior leaders in designing and executing future training programs that enhance member development and engagement.

Broad research has examined the relationships among values and attitudes, behavior, and decision-making. However, little is known about when and how values influence critical thinking (Verplanken & Holland, 2002), and even less is known about how deep-structured values and identity influence critical thinking (Horton et al., 2014). The limited research to date has explored the influence of a single value, while the complex nature of value structures has been neglected (Connor & Becker, 2003).

This study builds on previous studies that explain or support the processes at work to acquire and maintain marine identity and value traits (Ibarra, 1999; Riketta et al., 2006; Tajfel, 2010). Additionally, the article reviews how leaders may activate identity and energize value-congruent behavior, and how critical thinking contributes to adult development.

Social Identity Theory

The literature on social identity theory offers the foundational insights around the relationships among values and attitudes, behavior, and decision-making. Notably, social identity theory provides a generative construct that addresses how identity and values influence the broader meaning of leadership and decision-making. Peo-

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ple tend to arrange themselves and others into various social groupings (Ashforth & Mael, 1989; Collinson, 2006). Social identity scholars argue there is more to the psychology of groups than the functionalist paradigm of understanding organizations as masses of individuals conducting themselves according to their own motivations (Tajfel, 2010). Social identity theory contributes significantly to social psychology's ability to describe cognitive, preference, and critical-thinking processes of group and organizational thinking.

Individuals claim discrete category memberships with varying degrees of importance to their self-concept. The degree of importance influences how people think, feel, and behave. In their quest to understand the antecedents and consequences of social identities, Hogg and Abrams (1988) develop numerous major conclusions, noting that because individuals simultaneously belong to multiple social categories, their social identity construct is uniquely complex. Hence, because self-construct of individuals depends on the category with which they identify, the fundamental question, "Who are we really?" can be answered in many ways and depends upon the context (Kramer, 2003).

Hogg and Abrams (1988) state that one or more social identities are present at the core of one's self-concept, and others contribute secondarily or peripherally. For example, some marines' central social identity is largely defined in terms of their professional identity, which facilitates common slogans like "Once a Marine, always a Marine." Other marines' service in the Corps may not be as significant. Thus, their social identities as marines may be marginal and bear less influence on how or what they value (Kramer, 2003). Central social identities are important to every individual, and they will be motivated to affirm their central identities when necessary. This need for affirmation drives cognitive, preference (values), and decision-making processes.

The salience of any particular social identity, central or peripheral, varies across social contexts and is cued by them. The cued peripheral social identity is dominant among other sub-identities. The recognition of this depth of available social identities is important for the executive leader to maintain and provide continually appropriate cues that trigger particularly desirable identities. In this manner, social identities are, or can be, transformed by the crucible of interpersonal experiences (Kramer, 2003).

Situated and Deep-Structured Social Identities

The extant literature, building off the social identity theory discussion, offers empirical and theoretical literature on the acquisition, maintenance or sustainment, and loss of identity and values. These insights contribute to our understanding around the developmental events and their use in the acquisition and sustainment of identity and values, which are critical components to frame this study. Accordingly, at the end of this discussion, an examination of specific processes at work to acquire, maintain, and potentially lose marine identity and value traits are explored.

Identity

Identity bears significant emphasis in this study because it (a) provides an individual schema around which learning may be organized, (b) provides a foundation for an individual's motivational and subconscious guide that determines the extent to which an individual participates in developmental events, and (c) addresses an individual's personal narrative (Lord & Hall, 2005). As individuals mature, they not only rely increasingly on internal resources like identity to interpret their experiences but also tend to shift from individual to collective orientations.

The literature suggests that social identities exhibit either situated or deep-structured forms. One or more situational social identity may be prominent at any time and remain prominent as long as cues persist. While a situational social identity can be temporal and limited, a deep-structured social identity involves the transformation of one's self-construct, which includes characteristics (e.g., preferences and values), and more complex cognitive, emotional, and evaluative components. Once adopted or absorbed, a deep-structured social identity is more stable and less dependent upon prompts (Riketta et al., 2006). Because deep-structured social identities constitute a cognitive component of attachment (Riketta et al., 2006), they facilitate an enduring and readily available identity that evokes stronger emotion and evaluation than situated social identity. This transformation and maintenance of deep-structured social identities is essential to in-extremis organizations like the U.S. Marine Corps.

Within the literature, the construct of organizational commitment addresses a member's "emotional attachment to, identification with, and involvement in, the organization" (Allen & Meyer, 1990, p. 1). However, there is distinction between the constructs; commitment addresses effective and motivational strings of attachment that are not necessarily related to the self-construct (e.g., work variables such as reenlistments and performance). Conversely, social identity informs one's reactions to membership, whereas effective organizational commitment addresses reasons for maintaining a relationship with the organization (Meyer et al., 2007).

Self-Regulation

Self-regulation is the process of appropriately monitoring and adjusting thoughts, behaviors, and emotions (Day et al., 2009), and is an executive function of the self that depends upon "one's currently active identity, which may vary from individual, to relational, to collective" (Lord & Hall, 2005, p. 596). Most novice leaders are sensitive to social feedback and are likely to emphasize their individual identities and need of recognition and acceptance (Lord & Hall, 2005). Intermediate leaders are increasingly able to shift focus from themselves to others and comprehend context connectionist networks. As intermediate leaders shift toward relational identities, their actual or implied presence may elicit unique self-regulatory processes (Lord & Hall, 2005). Although they may convey a credible image, basic-level marines do not possess a fully elaborated professional marine identity and have yet to fully internalize Marine Corps social norms and rules. They continue to have "inner conversations," and their self-regulation remains vulnerable to undesirable influences.

The concepts of the possible and provisional self are types of self-schema that provide insight into self-regulation for basic-level marines. Day et al. (2009) identify the possible self as how someone desires to be or is afraid to be in the future. The possible self motivates how people behave and guides their pursuit of activities, and perhaps the values they reject or believe to be congruent. Ibarra (1999) suggests that individuals experiment with temporary and incomplete professional identities, called provisional selves, as they undergo life transitions. Kolb and Kolb (2009) explain that the concept of identity development has been further established and integrated with concepts relating to role modeling and experiential learning to explain the developmental process of creating and refining possible selves. First, individuals observe role models. Then, through active experimentation with the provisional self, individuals imitate the role model's behavior, attitudes, routines, and impression management tactics. Finally, individuals evaluate the effectiveness of the provisional identity against internal assessments and social feedback. The greater the self-assessment, social feedback, and accompanying values are, the more congruent the identity fit and accompanying values will be.

Values

If values are considered a fundamental characteristic of identity, then when and how do values affect critical thinking? "When" and "how" can be asked with the realization that values prime different identities (Lord & Hall, 2005). Values are part of humankind's deep-structured identity and direct thinking processes at an unconscious level. Values are not goals; instead, they are intimately connected with ethics (Stacey, 2012), and serve as reference points, aid in the construction of sophisticated understanding of contingencies, help establish priorities, and aid in discerning between good and bad, or appropriate and inappropriate (Johnson, 2012; Lord & Hall, 2005).

Values are cognitive; they assist in defining a situation and guiding actions (Lord & Hall, 2005; Verplanken & Holland, 2002). Values, however, are not prescribed or chosen; they are not consciously activated or rationally produced. Instead, values emerge in specific action contexts (Stacey, 2012) and develop through intense experiences and interactions with significant people. Therefore, both deep-structured values systems and deep-structured social identities are transformed, at least in part, in the crucible of interpersonal experiences (Kramer, 2003).

All branches within the armed forces have a primary means of instilling necessary cultural values and social identities that affect decision-making and behaviors within their personnel, such as the Code of Conduct and basic training regimens. For the U.S. Marine Corps, the primary means of indoctrinating a new member is boot camp (recruit training). In boot camp, recruits not only acquire knowledge about the Corps, but are also instilled with the cultural values of honor, courage, and commitment, along with the attitudes, customs, and courtesies of the Corps. Graduation from Marine boot camp is perhaps the defining moment in a marine's life. Nevertheless, while many values are culturally shared, all marines will differ in their personal prioritization and ranking of implicit values and marine identity, as values cannot be individually prescribed. An organization cannot attribute values to others, as this would form the identity, or self, of others. Values are emergent and require self-formation (Stacey, 2012). The task then becomes to facilitate members' mindsets to adopt new values and voluntarily act upon them. How might marines be brought to this willing state?

Deep-Structured Activation for Principled Values

Deep-structured social identity is the "taken-for-granted" value that develops principled problem definitions and underlies decision-making and action (Lord & Hall, 2005; Sharp, 1994). Although situated identities are required, they are insufficient to in-extremis organizations such as the U.S. Marine Corps (Meyer et al., 2007). Deep-structured social identities are preferable to organizations such as the U.S. Marine Corps because they are values-based, and therefore less dependent upon situational cues. They are more enduring and create a greater understanding of deep structures that define situational contingencies (Lord & Hall, 2005). However, the interest-based, unstable, and cue-dependent situated social identities can be transformed into deep-structured social identities. How are situated social identities transformed to deep structure? Once materialized, how are they sustained?

The literature provides numerous studies on the establishment and sustainment of situated social identities through the emphasis of (a) organizational successes, (b) external competition, (c) member-shared features, and (d) personal and organizational distinctiveness (Ashforth & Mael, 1989; Riketta et al., 2006). A review of the Marine recruit training instruction illustrates a concentrated effort on each of these stimuli. Further, such identities occur when situational cues make multiple social categories salient, causing the member to make comparisons, and resulting in self-categorization (Meyer et al., 2007). These cue-sensitive, temporary, and initial social identities are vulnerable to change as diverse categories become salient. The U.S. Marine Corps delineates its transformation process in five distinct phases: (a) recruitment, (b) recruit training, (c) cohesion, (d) sustainment, and (e) citizenship. As such, this study proposes that marines in the recruit and cohesion phases are not yet endowed with fully elaborated, deep-structured identities, and require value and identity "reinforcers" enabled through continued, planned, and experiential events to reinforce ways of acting they have not yet mastered.

As with knowledge structures, deep-structured social identity and values must be activated, but not all contexts influence the adoption of deep-structured identity and value development to the same extent (Tremblay et al., 2015). The critical factor in developing deep-structured identity and values is personal experience in varied relevant task environments (Lord & Hall, 2005). Further, as individuals gradually internalize the characteristics (e.g., preferences, values) of the social group, deep-structured social identities are more common among long-term members who have shared momentous events, where values have been the primary focus of attention to include crucibles, trigger events, and anchoring events. These values can continue long after the member has left the organization. Exposures to momentous events ingrain in members that one's values also benefit the group (Meyer et al., 2007) as well as the sense of "oneness with or belongingness to the organization" (Ashforth & Mael, 1989, p. 34).

Leaders are responsible for arranging reinforcing events that can be particularly important to young adults, such as basic-level marines, who often have many active sub-identities; it is never easy to demarcate clear boundaries between inappropriate identities (Collinson, 2006). Examples of underdeveloped marine identity and values erosion that lead marines to behave according to an inappropriate sub-identity have produced strategic implications. One example includes the 2012 video of Marine snipers urinating on a Taliban member's corpse. A second example is the 2017 scandal in which marines allegedly displayed demeaning and degrading content on social media, purportedly sharing nude photographs of female marines and openly harassing them.

Instrumental rationality and economic theories of critical thinking assume that members of an organization formulate their decisions through expectations and consequences, gaming them to arrive at the most beneficial and preferential outcomes. Social identity and values-based decision-making theories assume that organizational members will conduct sense-making by "identifying situations as matching identities, including the beliefs (facts) and norms (values) of an organization" (Torpman, 2004, p. 11).

While it is increasingly recognized that there are two important systems at work within critical thinking processes, namely the unconscious intuitive system and

Table 1

Results of Paired Comparison t *Tests on Sample*

Variable	Before MOS School Experience *M (SD)*	Before MOS School Experience *M (SD)*	*T*	*df*	*p*
Honor	15.03 (3.50)	16.00 (3.89)	2.74	230	.007*
Courage	12.42 (2.10)	12.62 (2.17)	0.96	230	.344
Critical thinking	9.86 (2.24)	9.68 (2.33)	0.86	230	.393
Marine identity	20.87 (2.96)	21.52 (3.16)	2.38	230	.018*

Table 2

Analyses of Variance (ANOVA) Results for MOS School on Key Variables

Variable	R^2	Adj. R^2	*F Ratio*	*p*
Honor	.03	.01	2.23	.09
Courage	.01	.01	0.23	.84
Critical thinking	.03	.01	1.95	.12

the conscious analytical system, much cognitive processing occurs subconsciously. Equally, there are two important influences on both systems: marines' deep-structured social identity and marines' deep-structured values. However, academia has either neglected or limited the concern of social identity and values. Informed by the growing scholarly interest in identity itself, this study addresses the importance of how identity and values contribute to understanding this process.

Materials and Methods

This study involves a sample of 231 marines across four MOS schools of the Marine Corps detachment on Fort Leonard Wood, which graduates an average of 7,500 students annually and where one of every seven marines receives their MOS training. The four MOS schools consist of Motor Transport Instruction Company; Military Police Instruction Company; Engineer Equipment Instruction Company; and the Chemical, Biological, Radiological, and Nuclear Defense (CBRN) School.

Two quantitative research questions were measured in a pretest and posttest design at the beginning and end of MOS training using Becker's (2013) instrument. The two quantitative research questions were,

1. What effect did the MOS school experience have on the marine's identification with the U.S. Marine Corps traits of honor, courage, critical thinking, and marine identity?
2. Did the effect on traits of honor, courage, critical thinking, and marine identity differ by MOS school?

To explain and contribute insight to the statistical results, the posttest instrument was complemented by six qualitative, open-ended questions to provide data regarding how the marines viewed their MOS school experience, how they believed it affected them as individuals, how it reinforced what they had learned in boot camp, and its impact on their commitment to the Marine Corps and its central values. The qualitative questions asked were, What are the student perceptions of the MOS training experience at Fort Leonard Wood, Missouri, and how does this experience shape their identities as marines? How do these identities affect their values orientations?

Informed Consent

Because marines are expected to comply with requests from authorities, protections were afforded to the marines, who are viewed as a vulnerable population under the Department of Defense Instructions (DoDI 3216.02, 2011). The voluntary nature of their participation in the study was explained, and the data were collected using methods that ensured the marines understood they had a choice regarding whether to participate before providing their written informed consent. The institutional review boards at the University of Charleston and the Marine Corps, as well as the Marine Corps survey officer, approved this research and concurred that the research team was following required protocols for the protection of human subjects.

Results

Quantitative Results

To test Research Question 1, paired sample t-tests were conducted to compare marines' values and identities from two time periods: before and after the MOS school experience. The scores of honor and marine identity increased significantly, and scores for courage and critical thinking scores did not change (see Table 1).

To test Research Question 2, a one-way ANOVA was conducted to compare the posttest scales on the four MOS schools: Motor Transport, Military Police, Engineering Equipment, and CBRN. The results indicated no difference between the

Table 3
Themes to Question 1 (N = 229)

Theme	MITC *n* (%)	EEIC *n* (%)	MPIC *n* (%)	CBRN *n* (%)	Total
Honor	42 (82)	36 (83)	26 (100)	9 (54)	87%
Courage	17 (29)	7 (23)	12 (46)	1 (8)	31%
Critical thinking	1 (2)	5 (17)	4 (15)	1 (8)	9%
Marine identity	28 (55)	25 (83)	26 (100)	8 (62)	73%

Table 4
Themes to Question 2 (N = 230)

Theme	MITC *n* (%)	EEIC *n* (%)	MPIC *n* (%)	CBRN *n* (%)	Total
Boot Camp	14 (12)	6 (13)	9 (24)	3 (15)	15%
The Crucible	59 (52)	16 (35)	17 (45)	7 (35)	41%
Boot Camp Leave	24 (22)	16 (35)	6 (16)	3 (15)	22%
Marine Combat Training	4 (4)	4 (7)	1 (3)	3 (15)	6%
MOS School	8 (7)	2 (4)	6 (16)	3 (15)	9%

schools on any of the tests (see Table 2). Quantitatively, the results confirm that the experience of the four MOS schools reinforces and sustains the basic-level marine transformation process, and the positive effects of the Crucible.

The qualitative strand of this research provided 1,364 responses from 231 respondents, providing rich insights into the marines' perspectives. Guest et al.'s (2013) two-phase analytic approach was performed on the responses. Phase 1 included a hypothesis-driven analysis that was confirmatory in purpose. Phase 2 included a content-driven, exploratory analysis that was inductive in its orientation. The marines indicated in varying degrees the importance of honor, courage, commitment, and other emergent themes, and supported their responses with examples of when and where these values were important.

Do You Like to Be Referred to as a Marine? Of the respondents, 216 affirmed they liked being called a marine, and 207 elaborated on why they like the title (see Table 3). This qualitative analysis parallels the quantitative results.

The respondents conveyed complex images of how they viewed themselves and believed others viewed them as marines. For example, a motor transport marine re-

Table 5
Themes to Question 3 (N = 229)

Theme	MITC *n* (%)	EEIC *n* (%)	MPIC *n* (%)	CBRN *n* (%)	Total
Honor	8 (7)	12 (27)	8 (20)	7 (33)	15%
Courage	2 (2)	12 (27)	4 (10)	4 (19)	10%
Critical thinking	3 (2)	6 (13)	4 (10)	4 (19)	7%
Marine identity	29 (24)	22 (48)	23 (57)	12 (57)	38%
Adult learning	5 (4)	0 (0)	2 (5)	3 (14)	4%
Just training	13 (11)	1 (2)	3 (7)	1 (5)	8%

sponded, "I do, but I have not 'accepted' the title within myself, because I am still not the Marine I envisioned myself to be."

The responses provided examples of how marines had accepted, renegotiated, and even rejected their Marine identities. While marine identity appears stable, it is viewed in terms of "not yet earned," and as a potential self, or what one hopes to become. Marine identity is not viewed as an individual identity, but as a service identity, requiring significant honorable experiences. For example, a CBRN marine responded, "I love being called a Marine. There is so much history and honor and pride behind the name that sometimes I believe I don't deserve to be called that until I see combat."

The marines realize they have embarked on a career not yet mastered and are still engaged in active experimentation. They recognize they are expected to embody the marine identity, which requires a rite of passage (see Table 4).

Describe the Defining Moment That You Realized You Had Become a Marine. As expected, the defining moments in which these marines realized they were marines were during boot camp and the Crucible. However, 37% of the marines viewed becoming a marine as a process or journey. For example, a marine engineer replied, "Over time I slowly started to realize it. I saw the decisions I would now make and compare them to my past and take pride in them."

When asked to identify the defining moment in which respondents realized they had become marines, 9% indicated that their recognition occurred during their MOS training. This suggests the MOS school experience involves an interaction in both psychological and social processes (see Table 5).

What Did the MOS School Experience Mean to You? Regarding an overall subjective observation of the MOS experience, 223 marines reported the school to be a positive experience, and six reported it was a negative one. The themes of identity as a marine, and vertical growth outside of acquiring MOS skills, were prevalent. For example, a CBRN marine reported, "With little oversight … it is here I began to

Table 6
Themes to Question 4 (N = 228)

Theme	MITC *n* (%)	EEIC *n* (%)	MPIC *n* (%)	CBRN *n* (%)	Total
Reduced commitment	7 (6)	2 (5)	2 (5)	5 (28)	7%
No effect on commitment	16 (14)	7 (16)	5 (12)	4 (22)	15%
Increased commitment	86 (79)	34 (80)	34 (83)	9 (50)	73%

Table 7
Themes to Question 5 (N = 219)

Theme	MITC *n* (%)	EEIC *n* (%)	MPIC *n* (%)	CBRN *n* (%)	Total
Everything taught	27(23)	23 (51)	21 (53)	8 (42)	7%
Marine identity	50 (43)	8 (18)	11 (28)	3 (7)	15%
Reinforced values	4 (3)	3 (7)	4 (10)	4 (22)	73%
Challenge	0 (0)	3 (7)	1 (3)	2 (11)	15%
Leadership	9 (8)	5 (11)	3 (8)	4 (22)	15%
It did not	19 (17)	4 (9)	2 (5)	3 (16)	15%

define, establish, and most importantly, implement the Marine lifestyle." A motor transport marine responded, "It meant for me that I was finally taking life into my own hands and starting my journey as a Marine."

The linkage between the MOS school experience and sustaining or developing identity is strong. However, the linkage between the MOS school and critical thinking is not.

How Did the MOS School Experience Affect Your Commitment to Being a Marine and Upholding Marine Corp Values? Of the respondents, 73% stated the MOS experience increased their commitment to be a marine and uphold Marine core values (see Table 6). A Marine engineer wrote, "Given the greater freedom, we have an opportunity to better learn who we are ourselves. Being able to make my own choices, I had to learn how to use my own judgment. I grew." Another marine in motor transport said, "It taught me that no matter how long you've been in, you've never really 'made' it because you'll always be a work in progress; you may be the best version of yourself so far but there's always room for you to grow/learn and seek self-improvement."

Table 8
Themes to Question 6 (N = 229)

Theme	MITC *n* (%)	EEIC *n* (%)	MPIC *n* (%)	CBRN *n* (%)	Total
Honor	20 (17)	9 (19)	3 (7)	6 (29)	18%
Courage	15 (13)	11 (23)	6 (15)	5 (24)	21%
Critical thinking	3 (2)	1 (2)	2 (5)	0 (0)	4%
Marine identity	78 (65)	24 (52)	28 (68)	9 (43)	78%
Leadership	2 (2)	4 (9)	0 (0)	0 (0)	3%
Other	1 (1)	1 (2)	1 (2)	1 (5)	2%

The themes of commitment to being a marine and organizational values were strong among all four MOS schools. However, seven percent of the respondents indicated that their MOS school experience did not positively affect their commitment to be a marine and uphold the core values. Most of these individuals expressed disappointment in the lack of warrior culture, and those themes centered on social engineering efforts (see Table 7).

How Did the MOS School Experience Reinforce What You Had Already Learned During Boot Camp? The analysis revealed that all four MOS schools broadly reinforced lessons learned from boot camp, marine identity, and leadership development. For example, a military police marine said it

> Helped me "settle into" myself as a Marine. Instead of instilling discipline, the MOS school developed discipline by giving junior Marines responsibility and taking off the training wheels—we study on our own or we fail on our own. No one holds our hand.

Another wrote,

> We had to make the right choices, we had to put in effort when no one was forcing us to. I feel as if I saw the fruits of my labor while others saw consequences. The MOS school was the first time it was on us and only us.

> The analysis showed that 15% said that the MOS school experience did not reinforce lessons learned in boot camp.

Commenting on this, one CBRN marine wrote, "The school was too soft, too slow."

Describe What It Means to You to Be a U.S. Marine. The most important theme and triangulation to the quantitative analysis stems from this question. Table 8 illustrates responses to this question. This triangulation suggests a high degree of congruence between their provisional construction and conceptualization of the kind of marine they are and the kind of marine they hope to be. Being a marine is about identity that is supported by honor and courage. Identity congruence is important because if it is self-justified, it is more likely to become internalized and deeply structured. Obligation to convey role identity will likely remain situated, if not discarded. This perspective is supported by Day et al. (2009), who suggest that leadership and identity are processes and not positions. Finally, here, there is a weak linkage between individual respondents' views of what it means to be a marine and critical thinking.

The literature suggests that when people adapt to new roles or are in a period of transition, they adapt to these new roles by experimenting with provisional selves, which serve as trials for possible but not fully elaborated identities. In the study, the marines reveal themselves provisionally; that is, being a marine is not necessarily how they view themselves, but how they hope others view them or who they hope to become. The marines in this study tend not to view identity in a historical construct but rather as a service identity, predicated by important prior experiences (combat) or as something they are doing.

Marines clearly acknowledge and reveal they are professionally immature, are immersed in a life requiring complex mannerisms, social customs, and courtesies, which clearly, they have not yet mastered. They are still developing their values and understanding how to live within them. To become fully elaborated and deeply structured, the marines will require continued cues and separation from their civilian identities and the incorporation of who they hope to become.

Discussion

There is convincing evidence that the four MOS schools sustain, and in some instances, enhance the transformation process in powerful and important ways. Further, the expectations of marines regarding MOS skill development and knowledge acquisition were met through the MOS school experience. However, while 26% of the marines reported increased critical thinking skills in the qualitative data, the quantitative data suggests otherwise. Consequently, the most novel outcome of this study is the realization that harnessing the potential of critical thinking and internalizing the Corps' central values is necessary for individual marines, and as early in their careers as possible. There is evidence to suggest that this is the ideal time to transcend and increase cognitive development within the instruction programs.

In Qualitative Question 3, the marines expressed dissatisfaction toward the behaviorism learning theory in which they are viewed as passive, and are merely required to respond to environmental stimuli, resisting the perspective that learning is something done to them. The qualitative strand revealed marine calls for both constructivism and cognitivist paradigms, wherein the learner is viewed as an information constructor and processor.

Recommendations

Marines only remember what they process and reflect upon. This is also true with self-regulation and internalization of core values. Learning and values inculcation must be processed to exist psychologically. This study suggests there is an exciting frontier in the marine transformation process that links MOS school training integrated with vertical development initiatives. It is likely that the marines' self-recognition of the need for vertical development would be a powerful catalyst to assist in curriculum development. These findings affirm the need for adult learning methods that engage the student marines' vertical development in addition to the horizontal MOS skill development; for example, beginning each training day with a period of reflexivity and evaluation.

The MOS instructors possess the occupational experience and skill set, but as a potential issue, this research suggests they are undeveloped in basic understanding of adult learning theory. To enhance the transformation and values orientation, it is clear the MOS schools must provide further educational opportunities for their MOS instructors. This finding presents an opportunity for future research regarding curriculum design within the MOS school environment with respect to enhancing vertical development. This study also suggests replication of this study within other MOS schools, to capture the progression and maturation of marines as their experience in the Marine Corps increases and as they have experiences in the operating forces.

Additionally, 22% of the respondents indicated that boot camp leave provided their defining moment in the realization of becoming a marine, while another 7% revealed they had lost their identities as marines and returned to their civilian identities. It appears that boot camp leave contributes more significantly to the transformation experience than has been previously suggested and may warrant additional attention. One suggestion might be greater linkage or a "hot hand-off" between the recruiter, members of the Marine Corps League, or even retirees, and the newly minted marine while home on leave.

Conclusion

This study investigates the efficacy of MOS schools in reinforcing and sustaining the basic-level Marine transformation process. It evaluates two different benchmarks in the MOS school experience: arrival at the Marine Corps detachment and during the marines' final week of training. Overall, the results reveal significant growth in honor and identity as a marine, and sustainment of the values of critical thinking, and courage across all four schools. As expected, marines increasingly draw on internal resources such as identities, values, and mental representations of both situations and expectations of marines during their developmental transition. Clearly, the trait development of marines must continue after boot camp.

The average age of the respondents was 21 years old. As such, their identities, values orientations, and internal compasses remain strongly cued by the opinions of others and are easily swayed or influenced by what they believe others want to hear. The marines at MOS schools still sense the tension between their yearning for their prior civilian identities and the distinctness of being a marine. They are in a state of transition. Their one year of service has not fully erased their 19 or 20 years of civilian identities, and they are still entering something new.

Working with other marines has always been the method of the Marine Corps leadership school, operating on the assumption that if one shows marines what good leadership looks like, those marines will be good leaders. However, until there is a greater focus on critical thinking, and vertical development is integrated into the MOS program of instruction, the most difficult challenge for marines will continue to be the limitations of the way marines "make meaning" at their current level of development.

Limitations

This study considers only four of over 32 military occupational schools. The disparity between the number of respondents and schools (MTIC 124 or 54%–CBRN 19 or 8%) makes it hard for relevant and accurate conclusions with respect to Hypothesis 2.

Finally, challenges exist in the application of these findings to all marines and leaders due to their different lives and learning experiences (Day et al., 2009). Variables such as prior exposures may increase or decrease feelings of intensity or stress responses as well as sex, cultures, and other demographic variables, all of which will cause different interpretations of the events.

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The Cost of Compliance

A Call for Context in Military Behavioral Compliance Training

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Abstract

The military continues to experience adverse effects on morale and readiness created by sexual assault, suicide, and other behavioral misconduct. Despite mandatory behavioral compliance training programs, continued violations of ethical behavior standards prove challenging to overcome. This article offers a hypothesis suggesting that aligning behavioral compliance training with unit readiness activities may more effectively achieve ethical behavior outcomes. It also calls for further research to establish a model instructional designers can offer to compliance program unit representatives that helps correlate job-specific tasks with ethical behavior outcomes.

The military continues to experience adverse effects on morale, trust, and unit cohesion caused by behavioral issues such as suicide (Harmon et al., 2015; Lopez, 2019) and sexual assault (Holland et al., 2014; Protect Our Defenders, 2020; U.S. Commission on Civil Rights, 2013). The military experiences comparatively similar rates of suicide (Lopez, 2019) and sexual assault (U.S. Commission on Civil Rights, 2013) to peer civilian populations, but the unique nature of military culture and elevated expectations for behavioral conduct of military service members place additional scrutiny on these and other behaviors. This increased scrutiny requires proactive interventions to address these behavioral issues. Congressional oversight has resulted in the creating of multiple programs (Defense Suicide Prevention Office, n.d.; U.S. Department of Defense [DOD], 2020) by the DOD to study the causes of and develop mechanisms to prevent or limit the incidence of unethical behaviors in the military.

Notwithstanding myriad training programs employed to remedy behavioral misconduct in the military, rates of sexual assault (Protect Our Defenders, 2020) and suicide (Lopez, 2019) remain consistent, with more recent periods seeing an increase (Baldor & Burns, 2020). Behavioral issues like sexual assault, suicide, hazing, and substance abuse are multifaceted (Harmon et al., 2017). These issues have many contributing factors that extend beyond the influence of the instructional design community. Instruction is, however, one of the primary strategies employed by DOD programs (Defense Suicide Prevention Office, n.d.; Sexual Assault Prevention and Response Office, n.d.). Addressing the psychological, cultural, environmental, and operational factors contributing to behavioral issues in the military is the responsibility of other professional fields. The instructional design community can use its interdisciplinary approach to develop instructional strategies that translate recommendations from these adjacent professional fields into achievable learning outcomes for service members. The continued addition of mandatory training requirements (Burke, 2017; U.S. Air Force, 2020; U.S. Army, 2018; U.S. Marine Corps [USMC], 2018b; U.S. Navy, 2020) with no appreciable decline in the incidence of sexual assault (Protect Our Defenders, 2020) and suicide (Baldor & Burns, 2020) should alarm those directing, developing, and delivering the training.

While the experience of each service and each service member is unique, this article acknowledges the broad similarities of compliance programs across the service branches. In the interest of brevity, declarative statements about "the military" will be supported by examples from the USMC. Additionally, given the extensive availability of data and scholarship, sexual assault and suicide will serve as representatives of the broader category of behavioral compliance training, including equal opportunity, hazing, substance abuse prevention, and others.

Additional research is needed to analyze the effectiveness of current instructional approaches used in military behavioral compliance training. I recommend a new integrative approach to conducting compliance training in the military. This recommendation solicits further research to establish a model instructional designers can offer to compliance program representatives to help them correlate job-specific tasks to ethical behavior outcomes.

Behavioral Compliance

Military law has governed behavioral ethics for as long as organized militaries have existed (Lanni, 2008). The Uniform Code of Military Justice (1950) regulates every issue from espionage and fraternization with the enemy to theft, hazing, rape, and murder. Across martial cultures, behavioral ethics and soldierly virtue are deeply en-

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trenched (Rowell, 2013), with each service branch having its own defined set of core values, including the Marine Corps' famed "Honor, Courage, Commitment" (USMC, n.d.). Recalling the military origins of John Flanagan's Critical Incident Technique (1954), today's military compliance professionals may introspectively observe extant training programs like leadership development and look externally to business and industry for examples of effective and ineffective execution of behavioral compliance training programs to guide military compliance training.

Organizational ethics and behavioral compliance in the corporate landscape is a comparatively new concept. Until the latter half of the twentieth century, many corporate strategies embodied the win-at-all-cost approach of the robber-barons (Waugh, 2019). As part of the Sentencing Reform Act of 1984, increased scrutiny over corporate ethics established seven recommended pillars for an effective organizational compliance program, including "proactive training and communication" (Waugh, 2019, The Organization on Trial section).

Since 1984, and with numerous examples of corporate misconduct (Investopedia, 2013), behavioral compliance has become an essential part of corporate risk management, often taking a mechanistic (Jackman, 2015) or "check the box" (Waugh, 2019, Compliance at a Crossroads section) approach. The corporate environment, like the military, struggles to limit or eliminate instances of behavioral misconduct despite the increasing number of firms adopting or expanding ethics and compliance training programs (Schembera & Scherer, 2017). Calls for new approaches to compliance training suggest that overcoming this stagnation of outcome is found in developing new, integrative approaches toward compliance training (Jackman, 2015; Waugh, 2019). Hauser (2019) advances a multidimensional conceptual framework that fosters practical compliance training through an alignment of various training strategies in a consecutive fashion.

Hauser (2019) argues practical compliance training raises awareness of organizational expectations for ethical compliance and informs managers and employees of an organization's expected adherence with said policies, thereby eliciting appropriate behavior within the organization. In its application, effective implementation of compliance programs and compliance training facilitates integrating ethical concepts into various workplace scenarios and contexts (Bell et al., 2017). This strategy of practical application is consistent with fundamental theories of instruction and learning.

Comparison of Instructional/Learning Theory in Military Compliance Training

The very formation of instructional design principles traces its roots to military training (Gagne, 1962; USMC, 2017a, see ADDIE). The ADDIE process (analysis, design, development, implementation, and evaluation) is the product of a partnership between the military and academia to create an approach for instructional systems development (Molenda, 2015). The military community employs systematic approaches to learning that incorporate the most prominent and widely accepted principles of learning and instructional design (USMC, 2017a). Although more than 40 years have passed since Mager (1975) introduced his criterion-referenced instruction principles, elements of that foundational approach continue to shape modern individual and unit training requirements. Yet, it is largely excluded from compliance training. Adopting the constructivist approach of contextual learning (Baker et al., 2009; Berns & Erickson, 2001; Kalchik & Oertle, 2010), individual commanders are delegated responsibility for their unit's mission readiness training. This approach is practical because commanders can contextualize the performance goals within the work environment that shapes learner performance. Still, while compliance training location, time, and venue are up to the commander (USMC, 2018a), compliance training content is centrally developed and prescribed at the service level (DOD, 2020). Finally, military training exemplifies the benefits of practice through cyclical readiness training. Yet, service members do not benefit from the same consistency of opportunity to regularly rehearse essential skills of behavioral ethics like bystander intervention or ethical dilemmas. This section discusses the application and misalignment of instructional and learning fundamentals to military compliance training.

Instructional Objectives

Mager's (1975) foundational research suggests that instruction should be objective-based and correlated to job performance. In Mager's view, proof of learning occurs when the learner demonstrates behavior changes (Lassonde, 2010). Consistent with this concept, each service branch employs a broadly similar approach to job-specific training programs for each occupational specialization within a unit. In the Marine Corps' approach, these individual skills aggregate to perform required unit skills known as mission essential tasks (MET; USMC, 2017a). In this model, training development and conduct are directly aligned to achieve unit-specific readiness outcomes that comprise the unit's mission-essential task list (METL). As expected, a unit's METL receives the preponderance of its operational training effort and regular evaluation by higher echelons of command. The cyclical approach and repetitive nature of MET training are consistent with learning theories suggesting essential skills or concepts that are most difficult to learn should receive repeated opportunities for learning (Khalil & Elkhider, 2016; Wurth & Wurth, 2018).

Unit METLs do not list behavioral compliance skills as METs. Instead, they are treated as ancillary professionalism skills required by service members to exist inside the military effectively. Perhaps this would explain the disassociation of behavioral compliance training from other unit readiness activities; however, individual physical fitness (USMC, 2018a), leadership development (USMC, 2017b), and organizational ethos (USMC, 2016) all receive regular training, practice, and evaluation despite not being listed on a unit's METL. Examples in business and industry suggest that rather than disassociating behavioral compliance initiatives from an organization's operational objectives, they should be woven into organizational structure and operations (Hauser, 2019).

The Marine Corps' Leadership Development Program tasks unit commanders to "deliberately integrate … Marine Leader Development into operations, training and unit activities" (USMC, 2017b, p. 4). An examination of the Marine Corps' governing order on sexual assault prevention and response (SAPR) (USMC, 2019) and its current guidance on SAPR training (USMC, 2018b) provide explicit direction for the frequency of delivery of centrally developed SAPR training packages but offers no similar verbiage charging commanders to incorporate SAPR training into a unit's operations. The theme repeats upon reviewing the Marine Corps' suicide prevention program (USMC, 2012).

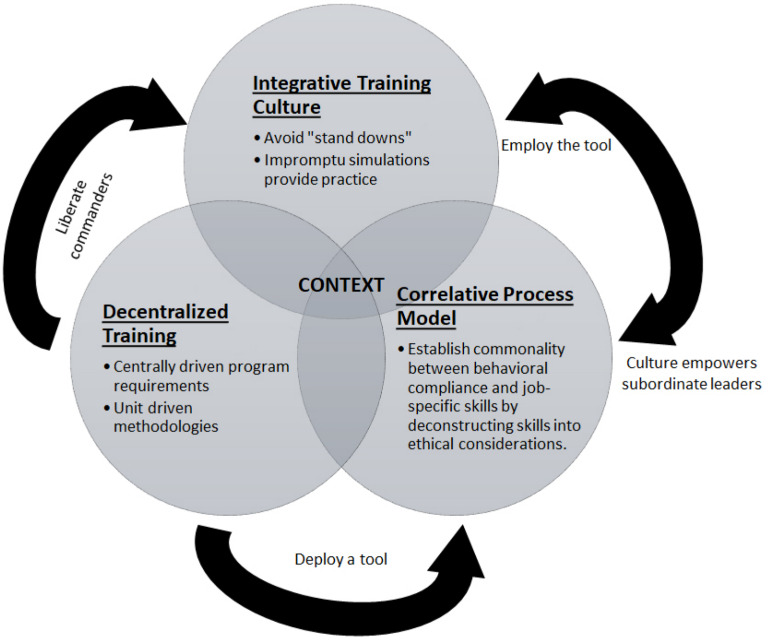
Decentralization

In learning and applying knowledge, context matters (Bell et al., 2017). Context enables learners to transfer what they learned through instruction and generalize its applicability to their given situation (Baldwin & Ford, 1988; Holton & Baldwin, 2003). In applying training to accomplish METs, occupational specialization communities periodically develop and offer community leaders their recommendations for individual and unit training requirements. This bottom-up approach to design ensures training remains relevant to each respective occupational specialization community. Individual units even contextualize universal training initiatives such as physical fitness (USMC, 2018a) and leadership development (USMC, 2017b) to the unit's mission and personnel.

In a departure from traditional approaches to military training, the development of behavioral compliance training is centralized, and its delivery format is specifically prescribed (DOD, 2020; USMC, 2012, 2018b, 2019). Unit commanders are responsible for maintaining unit-level programs and ensuring the mandatory training is delivered within the required time frame. Still, little flexibility exists to tailor this training to the context of an individual unit. This results in concentrated sessions of mandatory training that segregate the topics from a unit's primary mission readiness activities. This division may engender degraded perceptions of the legitimacy or efficacy of the training in the minds of service members (Saum-Manning et al., 2019).

The small fraction of an organization's time dedicated to compliance training and practice presents the most significant deterring effect preventing compliance learn-

Figure 1
Proposed Approach to Military Compliance Training



ing (Gentile, 2013). Competition for time to complete an ever-expanding list of compliance training requirements creates learner fatigue and limits a unit leader's ability to manage training effectively (Burke, 2016). The Army recognized this dilemma by removing some of its annual mandatory training requirements and increased flexibility afforded to commanders in how, when, and where they deliver that training (Myers, 2018).

Practice

Repetition and practice are essential strategies for effective learning (Williams, 2020). Of deliberate practice, Ericsson et al. (1993) argue expert performance is not the product of blind repetition, but rather by intentional efforts to improve performance through the targeted application of skill improvement. Gladwell (2008) furnishes numerous examples of individuals and organizations that achieve elevated performance levels through effective practice. One cannot overstate the importance of practice. That is why the military employs cycles of training that progressively build capability in a unit as it works toward an operational readiness goal. However, service members are not afforded the same frequent opportunities to rehearse skills that may help them save an at-risk service member's life or intervene in an ethically problematic situation that could lead to sexual assault. Outside of a short period of compliance training, the first opportunity for most service members to apply the skills they learn is during a crisis event. These events represent some of the most socially nuanced and ethically complex scenarios an individual can experience. Asking a service member to effectively intervene in a potential suicide, sexual assault, hazing incident, or managerial malpractice is akin to giving an administrative clerk an exposure-level class on infantry tactics then tasking him or her to lead a nighttime combined-arms assault on a well-defended position.

A New Approach to Military Behavioral Compliance Training

The issues of behavioral ethics are complex and multifaceted. Training translates readiness directives to service members. Still, training is only one component of a multipronged approach from numerous professional communities to raise awareness and improve behavioral outcomes. Mental health experts work to help service members overcome the unique stressors created by life in the military. Instructional designers should continually evaluate what, if anything, they can contribute to the improvement of behavioral compliance training in the military. This section offers three recommendations to improve DOD behavioral compliance training by amplifying instruction delivery and learner retention through the benefits of context.

Figure 1 illustrates the interdependent nature of the three recommendations. As the discussion shows, increased context results from the convergence of decentralized training approaches, an integrative training culture, and a new model to correlate behavioral compliance outcomes to unrelated job skills.

Decentralized Training

The development of training for all behavioral compliance programs should be guided by centralized policy but decentralized to unit commanders for contextualization within the mission and unique characteristics of each unit. In their review of five different suicide prevention programs, Harmon et al. (2015) found lower suicide rates in units with contextualized prevention programs.

In the Marine Corps' fundamental doctrine of maneuver warfare (USMC, 1997), decisions are delegated to the lowest possible level, recognizing that those closest to the point of friction are often the best informed to make timely calculations on the most effective means to alleviate that friction. Governing service policy should require incorporating essential points into the development of commanders' training programs. Still, the mandated delivery of prepackaged and scripted instruction ignores the special trust and confidence placed in commanders. It also denies established research suggesting behavioral compliance training is most effective when contextualized within an organization (Baldwin & Ford, 1988; Bell et al., 2017; Harmon et al., 2015). Decentralized training affords commanders the flexibility to contextualize behavioral compliance training within the mission, environment, and social fabric of their unit.

Integrative Training Culture

Consistent with examples from business and industry, commanders should take an integrative approach to behavioral compliance training that applies established learning theory (Ericsson et al., 1993; Williams, 2020) for repetition and job skill association. Taking an integrative approach to behavioral compliance training contextualizes training within the realities of a given unit. This integrative training culture is already embedded into the innumerable units that include the Leadership Development Program in everyday, regular operations.

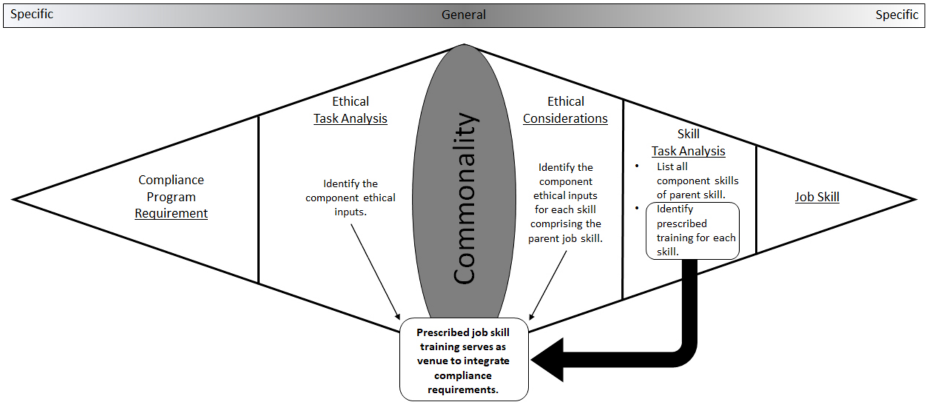
The standard approach to conduct compliance training compartmentalizes the instruction within "stand-downs" segregated from operational training (Leipold, 2012). An integrative approach incorporates the essential points of the given behavioral compliance program throughout the training calendar as a matter of unit culture. A typical example of integrating leadership development into normal operations is to allow a junior enlisted member to lead a formation or conduct an impromptu period of instruction on a general topic. This strategy requires little or no planning and occurs organically in units with effective leadership development cultures.

An integrative approach to compliance training empowers young officers and noncommissioned officers to continually integrate and contextualize behavioral compliance exercises into their daily battle rhythm. This integration occurs as quickly and organically as a young, enlisted member who is tasked to lead a formation to develop his or her leadership presence. Such an approach is, admittedly, a sea change from current techniques that segment compliance training from other readiness activities.

The Navy's new guidelines to incorporate andragogical techniques, like scenario-based and group training (U.S. Navy, 2020), will likely enhance the effectiveness of behavioral compliance training. Still, compartmentalizing these methods into yearly packages of training creates implicit qualitative classifications between operational activities and training (essential) and behavioral compliance training ("check the box") (Saum-Manning et al., 2019; Waugh, 2019). Instead, techniques such as role-playing exercises, vignettes, and impromptu simulations of hazing, suicidal ideation, or a sexual assault report should be interspersed throughout the training calendar. This ensures members receive opportunities to apply the compliance training concepts before they are required to do so in a real scenario.

Figure 2

Example Correlative Process Model



A New Framework for Learning Transfer

As this article continually affirms, context matters, and enhancing context requires associating the desired learning outcomes to the learner's environment (Berns & Erickson, 2001). Decentralizing training liberates commanders to contextualize behavioral compliance concepts and fostering an integrative training culture provides the mechanism to conduct the training. Still, another tool is required to help compliance program unit representatives correlate behavioral compliance outcomes to the job skill training activities within a given unit. The development and adoption of a model is essential to enable the success of the first two recommendations.

Figure 2 represents a nascent conceptual approach to correlating behavioral outcomes to other job skill training activities. It begins on either end with greater levels of specificity. The correlative process model generalizes toward the center as it works to establish commonality between the behavioral compliance requirement and a specific job skill. In its current state, it is not intended for application. Instead, it exists to depict what is meant by a correlative process model. This article calls for the investment of additional scholarship to develop, test, and refine a functional correlative process model that helps compliance program unit representatives contextualize program requirements inside the mission training activities of their unit.

Following the approach of Figure 2, the left side explicitly lists behavioral compliance program requirements. As a form of task analysis, the model considers the specific program requirement's ethical inputs. SAPR training, for example, requires service members to be apprised of bystander intervention techniques (USMC, 2018b). The ethical task analysis lists considerations needed to intervene effectively. Examples of those considerations are courage, selflessness, and judgment.

The right side of the diagram lists a specific job skill. For this example, the required skill is to conduct maintenance on a radio. Conducting a task analysis creates a list of component skills necessary to complete maintenance on a radio. Skills such as using an ohmmeter, testing batteries, and performing inspections of the radio's associated items are needed to maintain that radio. Each of those component skills are thematically correlated to ethical considerations like teamwork and commitment. The dark arrow places the extant training required to develop proficiency in the job skill at the point of commonality between behavioral program requirement and job skill. This training is how the program representative fuses ethical considerations from the compliance requirement with those of the job skill.

Conclusion

This article provides background and context for current approaches to conducting behavioral compliance training in the military. Comparative examples from business and industry demonstrate the effectiveness of integrating behavioral compliance throughout the structure and operations of an organization to achieve desired behavioral outcomes. This concept is not new in the military. Other ancillary training efforts are already incorporating into the regular battle rhythm of units.

A new method along three lines of effort creates an integrative approach to behavioral compliance training. Through this approach, a unit contextualizes the behavioral compliance program concepts and requirements into its mission, environment, and people. Decentralizing training methodologies to commanders affords them the flexibility to tailor program requirement training within their command. Once training is decentralized to commanders, they should foster an integrative training culture where subordinate leaders are empowered to incorporate behavioral compliance concepts as opportunities arise. Similar approaches already incorporate leadership development and physical training into other operational activities. Finally, instructional designers should pursue research that develops a correlative process model for compliance program unit representatives. This model would help program representatives contextualize behavioral compliance outcomes to job-specific training. By creating such a model, instructional designers will proactively engage the issues of behavioral misconduct that continue to degrade trust, morale, and mission effectiveness within the ranks of military service members. ☙

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Nontechnical Skills

A Development Hierarchy for Military Teams

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Abstract

Military operational contexts are highly dynamic, implying that military personnel should develop technical and nontechnical skills for performing tasks and missions. Nontechnical skills (NTS), as they promote reassuring performance, are preponderant for military teams. Therefore, it is essential to examine the relevance of NTS in this context and identify the main NTS to be developed. We performed an integrative literature review on nontechnical skills to identify the most important in military context. We determined that situational awareness, decision-making, communication, teamwork, and team leadership are the most important values for military teams. We propose a hierarchical skills development scheme for nontechnical skills fundamental for the military context.

They are not new or mysterious skills but are essentially what the best practitioners do in order to achieve consistently high performance and what the rest of us do "on a good day." (Flin et al., 2013, p. 3)

Membership in the Armed Forces implies that individual performance is taken to an extreme level, with a continual improvement of skills, to achieve the necessary perfection for actual missions while training for operating different weapons systems and learning new tactics and new emergency procedures (Murphy & Duke, 2014). This continual improvement allows developing adaptable responses to the high dynamism of military operational contexts (Swezey et al., 1998).

Safe military operations are fundamental and require high levels of skills (Bertram et al., 2015). It is important to minimize errors, which are the root cause for incidents and accidents, and are often the difference between life and death (Espevik et al., 2011;

Nickens et al., 2009). Safe military operations rely on an extensive set of knowledge (implicit and explicit) and individual skills, both determinants for the mission's success.

Given this, this article intends to address the relevance of nontechnical skills (NTS) development for military team training, as NTS may contribute to high levels of performance (Salas & Cannon-Bowers, 2011), and to the reduction of human error (Flin et al., 2013). Our discussion examines the relationship between training and skills development, proposing a hierarchical skills development scheme for NTS while also considering the relevance that the implementation of an NTS training program can have for military teams (Cavaleiro et al., 2020).

Research Questions/Objectives

Upon examining literature sources on military team training and NTS to identify an NTS development hierarchy, the main questions addressed for our review: (1) Which NTS are used in high-dynamic environments such as the military context? (2) Are NTS pivotal for military team performance? (3) How can NTS be developed in military team training? Skills development is a mature topic in many research areas. For aeronautics, NTS are well defined through the Crew Research Management framework (Salas et al., 2006), but there is a lack of research in other military fields, though importance of NTS for navy officers and other warship crew members has been recognized (Conceição et al., 2019; Sellberg, 2017). It is vital to perform an integrative literature review, considering its value for contributing new insights about NTS in the military context. This article presents a literature review to extend the NTS theoretical framework. First, we describe the methodology used for the integrative literature review on NTS development. Second, we present our findings, considering the main NTS used in high-dynamic environments such as the military context, the role of NTS in military team performance, and proposal of a NTS development scheme in military team training. Third, we reflect about the relevance of NTS for individual and team performance in the military context.

Theoretical Framework

Skills/Competence

Kerry (2013) reviews the research of many authors to define skills based on four main contributors. He starts with the critical incident technique developed by Flanagan (1954) in the U.S. Air Force, the competence model of McClelland (1973), and ends with the model by Spencer and Spencer (1993), while integrating the earlier models developed with the military. More recently, Boyatzis (2008) notes that emotional, social, and cognitive skills are pivotal for professional performance, in addition to management skills (Chouhan & Srivastava, 2014).

Military Context

The military context functions through a well-defined and well-established hierarchy (Hontvedt & Arnseth, 2013). The hierarchy relies on command functions performed by military leaders based on their leadership and management skills (Arbuthnot & Flin, 2017), decision-making, and risk assessment (Arbuthnot, 2017). The military context is characterized by high time constraints, high risk-to-life situations, and high levels of stress (Sarna, 2017). NTS development has become more relevant to overcome constraints associated with training and human resources management in the military (Kerry, 2013).

Sampling Frame and Data Evaluation for Literature Review

An integrative literature review on NTS was performed. The authors synthesized relevant information from sources about NTS development. This information can be used for the construction of a theoretical model or framework, such as our proposed conceptual model on NTS development for military teams (Snyder, 2019).

First, we have selected literature sources using the combination of the following keywords: nontechnical skills, armed forces, team training, military team training, and skills development in Google Academic. We have used Google Academic for systematic searches performed from June to July 2019 and April 2020. The results were not limited by dates of article publication. We have considered the following inclusion criteria: studies conducted with teams operating in dynamic environments focusing on NTS development and related to maritime safety and human factors; studies published in English only in peer-reviewed journals. We have excluded studies concerning NTS with no impact on team training or skills development. With this step, we included from mature to new topics on NTS and compared the evidence on NTS development from different research fields over time. The search resulted in the identification of 527 studies. The authors read each piece of literature to identify the main ideas and themes emerging from each article, resulting in the selection of 234 studies. Then, to obtain more updated information, we have restricted the review period to the last five years, using the main themes emerging from the first step of the integrative literature review. We have also included terms relating to NTS adapted from the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (2012): situational awareness, decision-making, communication, teamwork, and leadership. That strategy reduced the articles to 25 studies used in the review. The primary evidence emerging from the literature sources was summarized, synthesized, analyzed, interpreted, and aligned to the three research questions. Our interpretations analyze the significance of NTS for military teams and relate the analysis to the literature sources. We also checked for the inclusion of additional evidence from the selected studies from the referenced literature. The table presents the overview of reviewed studies.

Findings

Theme 1: What Are the Main NTS Used in High-Dynamic Environments Such As the Military Context?

The term competence can be defined as an integration of individual knowledge, skills, and attitudes used to perform a specific task (Aguado et al., 2014). To understand the evolution of the term competence, we will explain each of the competence models in more detail, focusing on the critical incident technique (Flanagan, 1954),

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Table

Main Findings on NTS Development for Military Teams

Reference	Aim	Findings
Conceição et al. (2017)	Development of behavioral marker system for rating cadet's NTS.	Five skills were identified: situational awareness, communication, decision-making, teamwork, and leadership.
Kerry (2013)	Framework on competency in the military.	Competencies for military teams include leader and individual skills, as well as knowledge (tacit and explicit); NTS are high level skills, including leadership and decision-making.
Nguyen et al. (2015)	Examination of simulation-based training on NTS performance.	NTS include cognitive and social skills and personal resources enabling a safer and efficient task performance.
Håvold et al. (2015)	Examination of simulation-based training effectiveness.	NTS referred to as tools for mitigating human error.
Hardison et al. (2015)	Transfer of skills taught to the military to civilian workplaces.	NTS are the most important skills for military personnel performance.
Tvedt et al. (2018)	Evaluation of Bridge Resource Management effectiveness for training commercial shipping fleet.	Low situational awareness can lead to a higher probability of accidents.
Sellberg (2017)	Systematic review of use of simulators in maritime education and training.	NTS are pivotal for military personnel performance and may be developed using simulation-based training. Situational awareness, decision-making, teamwork, and leadership referred to as the most important for military personnel operating in maritime environment.
Sellberg et al. (2018)	Examination of role of instructors and competencies assessment in simulation-based learning environments.	Brief and debrief techniques used for communication can improve organizational and team learning.
Delugach et al. (2016)	Examination of knowledge capture for acquisition of team mental models.	Good communication channels are essential for team elements' coordination.
Rico et al. (2017)	Development of a predictive model for understanding the contribution of motivation to team performance in interdependent systems.	Teamwork is determinant for the functioning of organizations.
Saeed et al. (2019)	Identification of essential NTS for merchant marine deck officers.	Overcoming problems associated with communication and teamwork allows the achievement of established safety levels, both for individuals as well as teams.

Table

Main Findings on NTS Development for Military Teams (continued)

Wahl (2019)	Examination of simulator fidelity in simulation-based training used for collaborative learning activities.	Incident command skills, such as leadership, team efficiency, and safer operations are achieved through simulation-based training.
Röttger et al. (2013)	Adaptation of Crew Resource Management Attitudes Questionnaire (CMAQ) to maritime domain.	NTS are essential for teams functioning in extreme conditions.
Ogle et al. (2019)	Evaluation of knowledge, skills, and abilities (KSA) in personnel assigned to operational military units.	NTS development allows continuous development of military teams.

competence model of McClelland (1973), competence model of Spencer and Spencer (1993), and Boyatzis' model (2008).

Flanagan (1954) intended for the critical incident technique to provide an easier way to create psychological principles and solutions for practical problems based on direct observations of human behavior. This technique uses many different instruments, such as interviews. These instruments are used to evaluate individual proficiency directly related to specific tasks, translated into behaviors (Flanagan, 1954). This technique was designed to understand the relationship between a particular action and the intention underlying that behavior (Boyatzis, 2008).

McClelland (1973) introduced a new approach to performance: individual competence is the origin for differentiating performance (Boyatzis, 2008). According to McClelland (1993), personal competencies are more relevant than intelligence and are determinant to execute tasks. Boyatzis complemented McClelland's model, mentioning that only a limited set of competencies would be a descriptor for work success (Alliger et al., 2007). McClelland developed the behavioral event interview based on Flanagan's critical incident technique (1954), defining high and low performance levels (Marrelli, 1998).

The competence model, developed by Spencer and Spencer (1993), includes eleven management competencies, such as analytic thinking, initiative, self-confidence, team leadership, teamwork (Dainty et al., 2004), and individual reward (Spencer & Spencer, 1993).

Lastly, Boyatzis (2008) argues that we could look at competence as an ability, based on different behaviors called intentions, organized around a subjacent construct and appropriate for many different situations. Boyatzis (2008) considered cognitive competencies (e.g., pattern recognition), emotional competencies (e.g., self-consciousness, self-control), and social competencies (e.g., interpersonal relationship ability) essential for individuals in professional domains. Competencies include different individual characteristics used for performing a complete task (Brightwell & Grant, 2013; Marrelli, 1998). But how can an individual develop competencies in a military context?

Competencies include different levels: individual, work, team, unit, mission essential, mission-specific, force, and core (Kerry, 2013). For military groups, competencies can be analyzed through the Command Team Effectiveness Model, integrating operational conditions, processes involved, and team action outputs, based on learning cycles, states, and process adjustments (Essens et al., 2005). Operational conditions for military teams require leadership skills, knowledge (tacit and explicit), individual skills, attitudes, as well as task-focused and team-focused behaviors (Kerry, 2013). We consider that technical skills and NTS, included in work competencies, are essential (Kerry, 2013). Technical skills can be more specific and related to one task. NTS are high level skills that include leadership, decision-making, information management, and other skills (Kerry, 2013).

More specifically, when referring to cognitive and psychomotor abilities to perform a task, we use technical skills (Nestel et al., 2011). Individuals use technical skills to ride a bicycle, operate a weapon system, or maneuver a warship. Conversely, NTS corresponds to cognitive and social skills and personal resources, enabling a safer and efficient task performance while complementing technical skills (Flin et al., 2013; Nguyen et al., 2015). These are the essential skills to avoid or detect a human error in time to implement the necessary alterations and to avoid an adverse event, thereby mitigating human error (Conceição et al., 2017; Håvold et al., 2015) that can affect individuals and materials drastically (Flin et al., 2013). The five NTS pivotal for operating in high-dynamic environments are situational awareness, decision-making, communication, teamwork, and team leadership (Flin & Maran, 2015). In the military context, these skills are equally referred to as the most important for military personnel when considering how NTS affect performance (Alliger et al., 2007; Hardison et al., 2015; O'Connor, 2011; Röttger et al., 2013; Salas et al., 2006; Sellberg, 2017). Considering the five NTS pivotal for operating in high-dynamic environments, it is now relevant to define each one individually.

Situational awareness is comprised of three steps: perception of environmental elements, comprehension of their significance in a restricted space and time, and projection in future events (Endsley, 1995b). This skill relies on three essential elements: gathering information, interpretation of data, and anticipation of future events (Flin et al., 2013). Each military team must understand how the battlefield is functioning and how to execute the assigned mission (Endsley & Robertson, 2000; Flin et al., 2013; Saner et al., 2009). Situational awareness is precursory to decision-making, based on previous experience and training of the military team (Endsley, 1995a). This cognitive skill is affected by the same constraints that affect mental ability (e.g., fatigue, stress, distractions, interruptions, and overstimulation) (Flin et al., 2013). Situational awareness is positively associated with concentration and individual capacity to focus (Flin et al., 2013). When low situational awareness levels exist, accidents have a higher probability of occurring (Tvedt et al., 2018).

Decision-making is the necessary process to accomplish a judgment or select a response option, allowing one to solve a problem fulfilling the situation necessities (Flin et al., 2013). The decision-making process occurs through the evaluation of a case (corresponding to situational awareness), problem definition, evaluation of one or more response options, selection and implementation of a response option, and analysis of the results (Flin et al., 2013). It is fundamental for the operational level (Thunholm, 2004). Military teams, without this skill, cannot collect the necessary information and quickly make decisions (Flin et al., 2013) about the actions required to accomplish the mission. Decision-making can be affected by different factors, such as technical proficiency, experience, situation familiarity, stress, fatigue, noise, distractions, and interruptions (Flin et al., 2013).

Communication is an information exchange between individuals, through which feedback, ideas, or feeling can flow (Flin et al., 2013). It relies on four elements: transmission of concise and precise information, context and intention included during information exchange, information reception, and identification of communication barriers (Flin et al., 2013). Straightforward and pragmatic communication is determined by organizational norms and training (Flin et al., 2013). Briefing is a typical communication process performed in the military context, essential for any training or mission. In this communication process, the military personnel can understand their objectives (Flin et al., 2013). Military teams using briefing and debriefing can analyze their training or mission through individual, team, and organizational learning lenses (Sellberg et al., 2018). The factors affecting communication can be the source of incidents and accidents, such as defects in communication systems, failures in message transmission and reception, emotional and rational interference, motivation, and individual expectations during the communication process (Flin et al., 2013). When a high volume of communications is necessary, such as in the military context, exemplary processing of information and proper communication channels (Whelan & Teigland, 2013), as well as the coordination between team elements (Delugach et al., 2016) is paramount.

Teamwork is crucial for any organization, acting as a bonding agent (Bates et al., 2013; Flin et al., 2013; Rico et al., 2017). Teamwork skills are attitudes and behavioral interactions that team elements must develop before working as a cohesive and effective team (Flin et al., 2013). Teamwork arises from four aspects: supporting others, conflict resolution, information exchange, and activities coordination (Flin et al., 2013). These aspects are pivotal in the military context (Salas et al., 1995; Shuffer et al., 2012). As with any other NTS, teamwork can have some associated problems. An imprecise definition of rules, the absence of explicit coordination between team elements, and communication failures can affect cooperation (Flin et al., 2013). The improvement of coordination solves teamwork-related problems and creates the necessary individual and team performance and safety levels (Saeed et al., 2019).

Team leadership arises when coordination and direction between team elements occur (Flin et al., 2013). The main aspects of team supervision are authority, pattern support, planning, prioritization, workload, and resources management (Flin et al., 2013). In a military context, leadership is exercised through command, corresponding to the authority conferred to a military commanding officer to direct, coordinate, and control military forces. The leader's decision is supported by a secure climate arising from team elements sharing information between them (Ornato & Peberdy, 2014; Smolek et al., 1999; Vogel-Walcutt et al., 2013). Military team leaders need adaptable incident command skills (Arbuthnot, 2017) that lead to safer operations, and improved team efficiency (Wahl, 2019).

With this, we conclude that the answer to our first research question is that the main NTS used in high-dynamic environments, such as the military contexts, are situational awareness, decision-making, communication, teamwork, and team leadership. Considering the main NTS used in high-dynamic environments, how can these skills affect military team performance?

Theme 2: Is This the Holy Grail of Military Teams' Performance?

Previously, we presented the definition for NTS and its use. In military context for the NTS development hierarchy, as well as for the functions that characterized each level of the pyramid, we verify that each hierarchical level of a military organization uses NTS differently. While lower hierarchical levels will execute tasks and missions, mainly using technical skills, intermediate and upper hierarchical levels will be much more specialized and will widely perform using NTS (Kerry, 2013).

Military personnel train and prepare to perform in an operational environment, using both individual and team skills (Bennett et al., 2013). Training is fundamental for military context (Noe et al., 2014), allowing individuals to develop the necessary skills (Kerry, 2013). Integrating simulated training with actual missions contributes to acquiring and developing mission-essential competencies, which can only occur after developing support competencies such as NTS (Bennett et al., 2013).

Mission-essential competencies allow military teams to function in the real world. At the same time, it is necessary to build a bridge between mission-essential competencies and the knowledge and skills acquired through training. This bridge corresponds to NTS development, and we may think of them as the holy grail of military team performance. These are support skills (Bennett et al., 2013) and include situational awareness, internal and external teamwork, and team leadership (Alliger et al., 2007). NTS allow individuals to interrelate, achieve better performance results, and act safely and efficiently (Salas & Cannon-Bowers, 2001). NTS serve as the glue for individuals and teams, functioning in extreme conditions (Hedlund & Österbeg, 2011; Röttger et al., 2016). Linking knowledge, skills, and essential mission competencies will be the basis for the NTS development hierarchy proposed above. It is fundamental to apply it, both in training and natural conditions, always looking for the continual development of military teams (Conceição et al., 2017; Driskell et al., 2018; Freeman & Zachary, 2018; Mansikka et al., 2017; Ogle et al., 2019).

These findings show that NTS allows individuals to achieve improved performance and higher levels of safety and efficiency, answering research question two: Are NTS pivotal for military team performance?

Considering the effect that NTS can have on military team performance, how can NTS be developed on these teams?

Theme 3: A Proposed Developmental Hierarchy

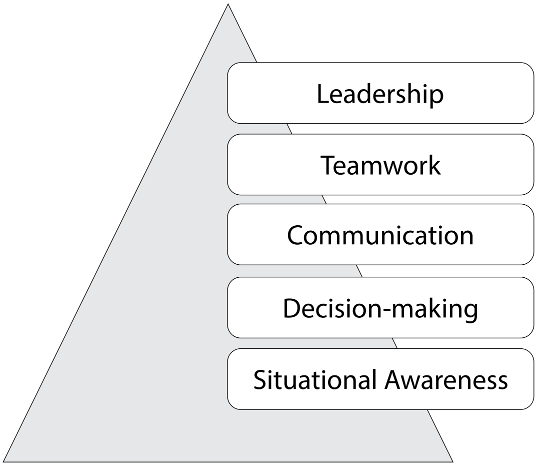
NTS development can occur through an evolutive pyramid, fundamental for individual and team performance. Understanding how teams can function, be successful, or fail is critical for achieving better performance (Freitas & Leonard, 2011), particularly for military groups operating in a wide variety of conditions (Bertram et al., 2015). But in which way does each NTS relate to and contribute to a skills hierarchy?

The correct analysis of the scenario where the team is operating is critical for decision-making, guaranteeing that every important element is identified (Gugliotta et al., 2017). It is fundamental to ensure two types of situational awareness for the team decision-making process: individual situational awareness and shared situational awareness (Flin et al., 2013). With this, we can argue that decision-making and situational awareness are profoundly interconnected (Endlsey & Selcon, 1997; Stubbings et al., 2012).

Teamwork relates to communication and decision-making. If communication does not exist, a team cannot function (Flin et al., 2013) or guarantee the success of an objective through obtaining a decision resulting from a process undertaken by interdependent elements (Orasanu & Salas, 1993).

Maslow (1943) proposed a motivational theory based on a five-level needs hierarchy, which was expanded to an eight-level hierarchy with further research (Maslow, 1970). Maslow's hierarchy of needs (1943) can be applied to education and learning, though we propose that would not be possible to pass to an upper level of the pyramid if all the needs from the lower levels were not fully satisfied (Hamel et al., 2003). Maslow's needs hierarchy (1943) can explain the NTS development; the following NTS can only be acquired after the full acquisition of the previous one. However, we have also to acknowledge Maslow's later work when he considered that this hierarchy is not rigid (Maslow, 1987). As military teams function in high-dynamic environments, individuals may adapt their NTS devel-

Figure
NTS Development Hierarchy for Military Teams



opment scheme to external conditions in order to achieve maximum performance. We propose a development hierarchy of NTS for military context, as presented in the figure.

According to this approach, situational awareness is the basis of the pyramid. If we do not understand where we are, it is impossible to work as a team, communicate, make decisions, or lead. If the team can develop a complete view of where the team is, then it is possible to identify the potential problems and their potential solutions through an appropriate decision-making process without accidents (Stubbings et al., 2012). It is possible to communicate if the necessary information is passed to other team elements resulting from the decision. The existence of updated data is fundamental in the military context (Louvieris et al., 2010), and communication plays an essential role in creating a web for sustaining teamwork. Lastly, the team leader will be responsible for aggregating knowledge, skills, and attitudes fundamental for achieving collaboration and accomplishing the assigned mission.

Military training programs can apply this NTS hierarchy, allowing military personnel to develop those skills and overcome all the factors that might influence the acquisition of each skill (Kehoe, 2013). This development hierarchy may provide the necessary and appropriate cognitive and behavioral modifications essential for skills development (Grossman & Salas, 2011). The education and training of military personnel can occur by applying the NTS hierarchy, contributing to fulfilling organizational needs (Wallace, 2013).

With this, we conclude that NTS can be developed through a hierarchical skills development scheme using military team training. This is the answer to research question three: How can NTS be developed in military team training?

An integrative literature review would not be complete without discussing its main implications for knowledge and considering future research recommendations. We have assumed that NTS development is a fundamental key for teams' evolution, maximizing individual and team performance. The NTS development hierarchy needs empirical validation to verify the proposed hierarchical and interrelated acquisition of situational awareness, decision-making, communication, teamwork, and leadership. For future research, we recommend designing NTS training programs specifically designed for military context, including individual and team development of NTS and its evaluation, through simulation-based training and training in real scenarios. The NTS hierarchy would be refined by evidence emerging from these programs and extend the findings on skills development of military teams.

Discussion

Our findings have focused on the importance of five main NTS for military team training and human error mitigation. It is critical to conceptualize its impact on adult learning. The learning character of military organizations can be enhanced through critical thinking, improving military education/ training, and assessing new development opportunities (Berg, 2020). Improving NTS levels of military personnel is essential for ensuring a better understanding of processes and effects (Khachadoorian et al., 2020) of individual actions on team processes and mission goals. At the same time, building strong linkages between explicit and tacit knowledge through NTS development will "improve the military's agility, adaptability, and speed of responding to any challenges presented by adversaries" (Babin & Garven, 2019, p. 3). NTS development and tacit knowledge are linked. First, this linkage arises from training and life experiences, contributing to mental agility and response to crises (U.S. Department of the Army, 2015). Second, the major role that NTS perform as cognitive and social skills and personal resources conducing to safer performance can also be associated with tacit knowledge (Flin et al., 2013).

Military leaders with well-established command functions, strong hierarchical and rule-based relations (Arbuthnot & Flin, 2017; Denning & Higgins, 2019), and high dependence on the availability of data and resources (Driskell et al., 2018) are the foundations of the military context. Military organizations have dedicated time to define continual education and training requirements that military personnel should complete to fulfill their functions (Khachadoorian et al., 2020). Any military operation that has clearly defined mission goals and team members to acquire the necessary skills for achieving that goal is pivotal to mission accomplishment (Goodwin et al., 2018). Team training using high-fidelity scenarios allows team members to acquire necessary skills (Grand & Kozlowski, 2013; McEwan et al., 2017).

Military operations are associated with dangerous life situations as well as with constraints concerning time and resources' availability (Sarna, 2017). It is crucial to share tacit and explicit knowledge and provide the necessary training for individuals and teams (Bertram et al., 2015; Kerry, 2013). In theme 1, we have considered that NTS, along with technical skills, may arise as the necessary tools for military organizations to overcome some human factor limitations by reducing the error chain (Håvold et al., 2015). With this theme, we have answered research question one: Which NTS are used in high-dynamic environments such as the military context? For teams operating in highly dynamic conditions, such as military teams, it is necessary to identify how to train those teams, ensuring an effective learning path and preventing skill decay. Simultaneous development of technical and NTS is the way to achieve safer operations, and improve team efficiency (Wahl, 2019). Simultaneously, preventing skill decay and enhancing team performance through the hierarchy of NTS development will allow military personnel to evolve from novices to experts on their functions, guaranteeing a continuum between explicit and tacit knowledge (Babin & Garven, 2019). We believe this is the future for military education and learning, thus leading to our conceptualization of NTS as the holy grail of military team performance, as proposed previously in theme 2. Here, we have discussed the importance of NTS to military team performance, and where we answered research question two: Are NTS pivotal for military team performance?

We believe that focusing team training processes on NTS development is pivotal for improving learning and training experiences. Through the development of a hierarchy of NTS, we believe that team training will better meet the present-day needs of military organizations, fulfilling a "multidimensional frame, blending formal, nonformal, and informal experiences that transcend time, space, medium, and format" (Bannan et al., 2020, p. 68). NTS development for individuals and teams contribute to reducing risks and accidents, as well as mitigate human error (Cavaleiro et al., 2020). Human error mitigation is possible by applying simultaneous technical and NTS development. This type of skills development is based on learning strategies (e.g., diversity in learning experiences, learning opportunities that go beyond instruction/training sessions design, cognitive load strategies, and connectivism-based strategies), and enhances learners' development through instructors' guidance (Bannan et al., 2020). We also propose that simultaneous technical and NTS training will delay skill decay, reducing the number of training sessions and improving team performance using implicit and explicit knowledge. There is a continuum between these two types of knowledge, allowing individuals to evolve from novice to expert stage in their functions (Babin & Garven, 2019). It is essential to "recognize the importance of assessing the knowledge over time and identifying the requirements that are needed to establish when an individual has become an expert" (Babin & Garven, 2019, p. 7). Technical skills and NTS are fundamental for achieving the necessary doctrine requirements for training and education. We assumed the complete acquisition of one NTS to enable the development of the next one in the NTS development hierarchy, improving the process of knowledge acquisition. This process is like the evolution from novice to expert: a beginner cannot move forward without enhancing his or her explicit knowledge (Babin & Garven, 2019), and his/her NTS of decision-making and communication. The expert has the experience, the implicit knowledge to solve problems (Babin & Garven, 2019), and the acquisition of the five NTS of our hierarchy. When an individual has an excellent situational awareness level, has acquired the decision-making process, and has developed good communication skills (Babin & Garven, 2019), it is possible to go further on the NTS development hierarchy. He/she has achieved the necessary implicit knowledge to become a team leader, with leadership as the top skill for NTS development pyramid. With theme 3, we have proposed a NTS development hierarchy, interrelating the six main NTS mentioned in the theme 1, and answering research question three: How can NTS be developed in military team training?

Conclusions

Technical and NTS development is pivotal for the success of military teams. We have advanced the theoretical framework on NTS development adapted to military teams using an integrative literature review. We argue that training should incorporate this development hierarchy to achieve safer performance conditions and timely identification of human error. Higher performance and better cohesion, fundamental for operating during peace and wartime, can be achieved by including NTS in training programs of military teams.

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Upcoming Conferences of Note

July 11–14, 2022: Anthology Together (Formerly Blackboard World Conference)

Walt Disney World Swan and Dolphin Resort · Orlando, Florida

https://anthology.com/together

Anthology Together is the destination for education professionals featuring keynotes by industry thought leaders, peer-driven discussions, best practices sharing, and a variety of networking opportunities. Learn from the best institutions and organizations in education on how they inspire and achieve greatness.

July 19–21, 2022: Army University Symposium

Fort Leavenworth, Kansas (hybrid)

https://armyuniversity.edu

This conference emphasizes evidence-based practice, educational innovation, and practical applications of theories and research findings in the field of distance education and online learning.

August 4–6, 2022: American Psychological Association Convention

Minneapolis, Minnesota (hybrid)

https://convention.apa.org/

The American Psychological Association (APA) Convention is the world's largest gathering of psychologists, psychology students, and other mental and behavioral health professionals. This is an opportunity to discuss education and behavioral sciences specifically tailored to the military population with a wide variety of experts.

August 16–18, 2022: iFest

Hilton Alexandria Mark Center · Alexandria, Virginia

https://www.ntsa.org/events/2022/8/16/ifest-2022

The DoD Advanced Distributed Learning (ADL) Initiative, in collaboration with the National Training and Simulation Association, provides unique opportunities for military, government, industry, and academia professionals to share the latest in distributed learning innovations.

October 10–12, 2022: Association of the United States Army (AUSA) Annual Meeting & Exposition

Washington, D.C.

https://meetings.ausa.org/annual/

The Association of the United States Army (AUSA) Annual Meeting and Exposition is the largest landpower exposition and professional development forum in North America. The annual meeting is designed to deliver the Army's message by highlighting the capabilities of Army organizations and presenting a wide range of industry products and services. AUSA accomplishes this task throughout the entire event by providing informative and relevant presentations on the state of the Army, panel discussions and seminars on pertinent military and national security subjects, and a variety of valuable networking events available to all that attend.

October 11–14, 2022: American Association for Adult and Continuing Education (AAACE) Conference

Hyatt Regency Milwaukee · Milwaukee, Wisconsin

https://www.aaace.org/general/custom.asp?page=2022-cfp

This is the annual conference of one of the nation's largest organizations for adult and continuing education. The American Association for Adult and Continuing Education (AAACE) is the publisher of three leading adult education journals: *Adult Education Quarterly*, *Adult Learning*, and the *Journal of Transformative Education*.

October 17–20, 2022: Institute for Credentialing Excellence (ICE) Exchange

Savannah, Georgia

https://www.credentialingexcellence.org/ICE-Exchange/Save-the-Date

The ICE Exchange conference is the conference for the credentialing community. The name ICE Exchange reflects what is valued most by our annual conference attendees: the exchange of industry trends and best practice through live education and networking.

October 24–26, 2022: Association for Continuing Higher Education (ACHE)

New Orleans, Louisiana

https://acheinc.org/ache-2022

The Association for Continuing Higher Education (ACHE) is a dynamic network of diverse professionals who are dedicated to promoting excellence in continuing higher education and to sharing their expertise and experience with one another.

November 8–17, 2022: Professional and Organizational Development (POD) Network Conference

Virtual

https://podnetwork.org/updates-events/46th-annual-conference/

The POD Network Conference focuses on the community of scholars and practitioners that advance the scholarship of teaching and learning through faculty development.

November 16–18, 2022: Council for Adult and Experiential Learning (CAEL) Conference

Chicago, Illinois (hybrid)

https://www.cael.org/events/2022-cael-conference

The annual conference brings together over 500 participants to learn, network, and work together to make lifelong learning accessible to adults around the world. Attendees include college faculty and administrators, human resources professionals, workforce developers, and representatives from labor and government.

November 28–December 2, 2022: Interservice/Industry Training, Simulation & Education (I/ITSEC) Conference

Orlando, Florida

https://www.credentialingexcellence.org/ICE-Exchange/Save-the-Date

This is the world's largest modeling, simulation, training, and education conference, allowing participation in education paper presentations and networking among government, industry, and academia peers and subject-matter experts.

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 continuously 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, call 913-684-2090 or 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 Courier New, 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.

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