

Technological Fluency: A First Step in Rethinking Army Training

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ABSTRACT

Advances in recent years have afforded Soldiers the ability to interact with exponentially greater volumes of emerging technologies, regardless of domain or work role. In many cases, the very manner and location in which a Soldier performs their tasks has drastically shifted as technology allows for work to be increasingly asymmetrical and distributed. The impact of technology will only continue to accelerate in the Future Operating Environment (FOE), as Soldiers are continually teamed with increasingly sophisticated and evolving technologies. While technology and new ways of conducting missions afford the Army with new opportunities to obtain success, it also presents a critical challenge as the rate of technological evolution outpaces the Army's current ability to provide technology-specific training in a timely manner. To address this problem, there is an ever growing need to be able to train individuals with an aptitude for technological fluency (TF) – a competency consisting of cognitive and noncognitive attributes that enable individuals to creatively use, synthesize, and adapt with evolving technologies to enhance performance. However, a model to describe TF does not currently exist, so there is first a research need for building an understanding of what enables an individual to be gifted with new technologies.

In this paper, we discuss how a competency model for technological fluency can be leveraged to train Soldiers. The preliminary work consists of two main subcomponents: (1) development of a technology ontology that maps a wide assortment of technologies that the Soldier of both today and in the FOE employ and (2) identification and organization of the necessary knowledge, skills, abilities, and other characteristics (KSAOs) to be technologically fluent. We discuss next steps for research to understand how/if Soldiers are currently being trained in the necessary competencies, and where training can be adapted to help Soldiers become more technologically fluent.

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INTRODUCTION

In the constantly evolving battlefield, tactics shift significantly from one conflict to another. Wars fought two decades ago are almost unrecognizable compared to today's conflicts. The Army's Multi-Domain Operations (MDO) initiative helps conceptualize this changing battle space, encapsulating "how we fight, what we fight with, and who we are" (Army Modernization Strategy, U.S. Army, 2019). This new battlespace requires innovation, adaptation, and leveraging of superior technologies to meet ever-changing demands. As technologies and assets advance, it is imperative that Soldiers adapt with them. Soldiers must understand how to employ technologies in rapidly changing environments and also utilize them to increase the effectiveness of U.S. forces.

Two examples illustrate this point. Hollnagel et al. (2022) describe a high stakes, near catastrophic, incident in which Air Traffic Controllers (ATCs) experienced a breakdown in their flight tracking software for approximately 30 minutes. The situation created the need and pressure to quickly transition to a different software system—a system they were not trained on—and figure out how to map plane information to flight paths to avoid collisions. ATCs collaborated with Information Technology (IT) specialists and nearby control centers to ensure flight plan information was complete and accurately communicated. Additionally, IT needed to quickly troubleshoot software issues to get the system back online. This incident demonstrates the importance of being able to adapt and creatively use technologies to problem solve.

In recent years, commercial drone technologies and production have advanced to make them lower cost, to have more compact designs, and to travel relatively far distances, without specific regard for military use cases. In the ongoing conflict in Ukraine, soldiers have masterfully employed these commercial drones in novel ways to devastating effect. Based on information available across various media sources, Ukrainian soldiers have used small commercially available drones to (1) deliver small explosives such as grenades and mortar rounds onto enemy positions at near zero personal risk and with pinpoint accuracy; and (2) guide friendly combatants and civilians to safety. These new use cases for drones were enabled by the advancements in technology, but it was also critical that these drones were operated by people skilled in terrain navigation, who understood munitions employment, and had sufficient engineering skills to mount equipment outside of the intended payload of the commercial apparatus. The individuals utilizing them also had to have the forethought to incorporate them into a mission in a way that they were perhaps not originally intended to be used.

Traditionally, U.S. Army training involves a structured curriculum designed to impart knowledge and skills related to specific equipment. This approach includes classroom instruction, hands-on lab sessions, and assessments to evaluate trainees' understanding and proficiency with the equipment. These courses are tailored to trainees' specific roles within the military. Selection of individual for training typically includes consideration of physical requirements, security clearances, and pre-existing qualifications. However, as technology evolves at an unprecedented pace, adapting quickly to new systems without formal training becomes crucial. Both examples described above illustrate that while it is imperative to understand the technical specifications of specific tools, it is equally important to understand ways in which systems can be adapted to meet unanticipated mission needs. Indeed, a necessary shift in focus is taking

place from training on specific technologies and operating procedures to more general training and encouragement of innovative, out-of-the-box thinking. The purpose of this research is to develop and validate a model of technological fluency that will aim to help the Army make personnel decisions (i.e., inform assignments) and train for this capability.

Defining Foundational Concepts

Before providing the details of this research, it is necessary to provide a few definitions of key terms. We first define *technology*, as there can be a variety of definitions depending on the context. For the purposes of modeling technological fluency for the Army, the term technology pertains to any tool, technique, device, system, and/or process that (1) is operationally relevant and significant, such that it pertains to the user's mission and its effects go beyond mundane, routine daily activities (e.g., a better cardboard box may be useful but is not significant); (2) has an interface that requires interaction by the end-user (e.g., joystick, writing code, F35 helmet calibrated by brain waves); and (3) requires acquisition of knowledge, skills, and/or abilities for effective or novel use. Technology can be incremental, achieving small increases in capabilities, or it can be exponential and highly disruptive.

To be successful in the FOE and within MDO, Soldiers must use, adapt, and combine technological tools to solve emerging or anticipated problems. Thus, for the purpose of this research, the operational definition of *Technological Fluency (TF)* is a competency consisting of cognitive and noncognitive attributes that enable individuals to creatively use, synthesize, and adapt with evolving technologies to enhance performance. This operational definition was developed by leading academics and Army scientists from the U.S. Army Research Institute for Behavioral and Social Sciences (ARI) and Army Research Lab (ARL) who determined it was important to consider both how to *use* a new or unfamiliar technology quickly, and how to *synthesize* and *adapt* with evolving technologies to meet mission needs.

Technological fluency emphasizes developing Soldiers' competency to intuitively understand, operate, and optimize new learning-capable systems. This approach focuses on equipping Soldiers with the cognitive flexibility and problem-solving skills necessary to seamlessly integrate emerging technologies into their operations, enabling them to achieve near-optimal performance with minimal formal instruction. By fostering technological fluency, the Army can ensure its personnel remain agile and effective in an increasingly complex and technologically advanced operational environment. This research aims to systematically define and organize the knowledge, skills, abilities, and other characteristics (KSAOs) into the competencies essential for assessing and developing technological fluency. This will enable the Army to assess Soldiers' proficiency levels to inform assignments, as well as augment training programs to focus on developing these critical skills, ensuring that Soldiers can adapt and excel with any technology they encounter.

In this paper, we will first discuss the development of a technology ontology that will be used to characterize technology in lieu of specific technologies, ensuring sustained relevance as new technologies emerge. Next, we will identify and refine the critical KSAOs through a rigorous front-end analysis, involving an extensive literature review and consultations with experts in the field. Finally, we will describe the development of a competency model to structure these KSAOs into higher-order constructs, allowing us to assess and train Soldiers effectively. Our hope is that this structured approach will help the Army enhance individual performance and maintain operational superiority by fostering a force capable of intuitive and creative use of advanced technologies.

DEVELOPMENT OF A TECHNOLOGY ONTOLOGY

The FOE will introduce Soldiers to technologies that they have never encountered before. Trying to anticipate how Soldiers will adapt to a specific technology would be unproductive. Many categories and examples exist, such as those outlined in the NASA Technology Taxonomy (Miranda, 2020) or the 14 Critical Technology Areas in the 2023 DoD National Defense Science and Technology Strategy. However, technologies continuously and sometimes rapidly evolve.

To represent the diversity in technology, we developed an ontology focused on how users engage with technology. This ontology will be used to map KSAOs to generalizable characteristics of technology rather than to specific technologies, ensuring the model remains relevant and applicable as new technologies emerge. The ontology, centered around User Engagement Characteristics (UECs) was created by synthesizing researcher observations and discussions with technology developers and Soldiers. The ontology provides a flexible, evergreen model capable of adapting to future technological advancements.

The idea to develop a list of UECs was conceived during observations at Driving Innovation in Realistic Training (DIRT) days, an event hosted by the Civil-Military Innovation Institute (CMI2) in partnership with the U.S. Army Combat Capabilities Development Command (DEVCOM). This event was developed as part of the U.S. Army's Catalyst Pathfinder program to serve a multitude of purposes: (1) fulfill annual training requirements for Guard units, (2) provide an avenue for hands-on field testing of innovative and emerging technologies from universities and commercial vendors, and (3) expose Soldiers to new forms of technologies. The unique setting, which included engineering maker spaces and Soldiers operating in a training scenario, provided an opportunity rich for information gathering.

Five researchers from the research team attended DIRT days. Upon arriving at the experimentation facility, they met with various engineers, including university and commercial partners. Soldiers tested various technologies, ranging from low-tech solutions (e.g., C-Wire handler) to high-tech equipment (e.g., robot dog). The researchers observed shared characteristics across technologies that require similar behaviors to utilize them. For example, in an interview, the robot dog operator noted how the controller was like a drone controller. The two technologies require the controller to manipulate multiple joysticks and make quick adjustments based on the movements of the technology. These observations sparked internal conversations among researchers about the need to determine ways to describe and group technologies by their intended use and in the specific user interactions. The idea was that identifying shared behaviors required to control a piece of technology would result in identifying the shared competencies and KSAOs required to perform those behaviors. Considering the ever-evolving nature of technology development, approaching the problem from this perspective allows us to create a model that characterizes new and current technologies. Following participation in DIRT Days, the team began preliminary development on a list of UECs that would be used to identify and define the various ways in which users engage with technology.

UEC Development

The initial conceptualization of UECs included 13 distinct attributes (e.g., physicality, frequency of feedback, cognitive load). Over several months, these attributes were refined through multiple rounds of review by subject matter experts (SMEs) from government and commercial research organizations who engage in technology research and development. This process included iterative reviews and discussions to identify and remove redundant UECs as well as those that did not lend themselves to classifying technology, leading to a streamlined and validated list.

To refine the list, the team developed a set of criteria by which to evaluate each UEC. The criteria were developed as a team to ensure that the UEC list was distinct from the KSAOs, and included non-overlapping characteristics that would be useful for classifying current and future technology. The following criteria were used to assess each UEC:

- Is the UEC a KSAO?
- Is the UEC redundant with other UECs?
- Is the UEC a combination of other UECs?
- Is the UEC outside of project scope (e.g., selection requirements)?

If the answer was 'yes' to any of these criteria, the researchers discussed and determined whether it should be removed or revised. Seven UECs, (e.g., autonomy, prior experience, physicality), were removed for not meeting at least one of these criteria. For example, while physicality can describe how a user engages with technology, physical abilities were considered outside of the project scope, as the requirements for interacting with the technology (e.g., lift over 50lbs) do not add any predictive power on how one will perform. Additionally, two new UECs—frequency and complexity of input—were added to address gaps identified in how users interact with technologies. Technologist SMEs then evaluated the revised list for clarity and relevance by providing ratings on a 1-5 scale. This review involved scrutinizing each UEC for its descriptive power and utility, resulting in additional refinements to improve the clarity. The final validated list included UECs such as frequency of technology feedback, clarity of feedback, physical proximity, cognitive workload, technological interdependence, degree of collaboration, frequency of user input, and type of user input. See Appendix A for initial and revised lists of UECs and descriptions.

After finalizing the list of UECs, scale anchors were developed based on the definitions of each UEC. Initial validation testing was conducted by three researchers independently rating nearly 70 representative technologies according to the UECs, ensuring the list's ability to meaningfully categorize different technologies. The list of 70 technologies was

developed by the research team with the explicit goal of including a range of technologies, such as those with simple user interfaces requiring minimal input to complex systems demanding high cognitive load and frequent user interaction. This exercise confirmed the face validity of the UECs, with a balanced distribution across the scales developed for each characteristic.

This final ontology provides a robust framework for classifying user interactions with various technologies, ensuring comprehensive coverage and meaningful distinctions. This validated list will be crucial for ongoing and future research in classifying future technologies to understand their similarities, specifically concerning the KSAOs required to operate them efficiently and effectively in various applications which will be covered in the next section.

IDENTIFICATION AND REFINEMENT OF RELEVANT KSAOS

The front-end analysis (FEA) aimed to create a comprehensive list of KSAOs critical for technological fluency. The purpose of this list is to serve as a foundation for developing a competency model and understanding the technological fluency landscape. The process began with an extensive literature review spanning military and civilian sources. Researchers utilized databases such as Google Scholar, EBSCOhost, and Defense Technical Information Center (DTIC), websites of specific government and Department of Defense organizations (e.g., U.S. Army, NASA, White House), and websites of relevant government research agencies (e.g., Army Research Lab, DARPA, Congressional Research Service, etc.). The focus was on sources from the past decade to ensure relevance to emerging technologies. Examples of keywords for civilian literature include terms such as “emerging technology,” or “emerging technology in industry,” whereas, for military/government related sources, search terms included “technological fluency in the Army/Military/U.S. Government,” “taxonomies/classifications of technology in the Army/Military/U.S. Government,” and “new military technologies.” Note that these keywords do not represent an exhaustive list of all search terms used for either the civilian or military/government literature reviews, but rather serve as a representation of the types of terms and phrases we used to identify sources.

Ultimately, researchers identified 37 sources for inclusion in the literature review, 21 of which were from civilian sources and 16 from military/government sources. Examples of particularly critical or important sources from both the civilian and military literatures include:

- A Digital Fluency Framework to Support 21st-Century Skills (Fleming et al., 2021)
- Proposed Managerial Competencies for Industry 4.0 - Implications for Social Sustainability (Shet & Pereira, 2021)
- Predicting the Use of Web-Based Information Systems: Self-Efficacy, Enjoyment, Learning Goal Orientation, And the Technology Acceptance Model (Yi & Hwang, 2003)
- Study To Establish Levels of Digital Literacy for Soldiers and Leaders in the U.S. Army (Mobley, 2011)
- National Defense Science & Technology Strategy 2023; DOD (U.S. DOD, 2023)
- Congressional Research Service: Emerging Military Technologies: Background and Issues for Congress (Sayler, 2022)

From the 37 sources, researchers identified 167 initial KSAO statements, which were then reduced to 140 after removing duplicates. To ensure the coverage of various Army jobs utilizing technology, researchers consulted O*NET, identifying 20 representative civilian jobs from a range of occupational specialties and extracting relevant KSAOs. For example, the civilian cyber job *Information Security Analyst* was used to pull the list of KSAO statements from the O*NET page on this job. After eliminating redundancies, 124 unique KSAO descriptions were derived from O*NET. Three researchers independently reviewed these descriptions for relevance, resulting in 71 additional statements that were incorporated into the final list. The rigorous methodology and systematic review ensured a thorough and relevant compilation of 211 unique KSAO statements essential for technological competency.

KSAO List Refinement

The next step was to refine the 211 KSAO statements by identifying thematically similar items using natural language processing to calculate cosine similarity between each pair of statements. Cosine similarity, ranging from -1 to 1, measures semantic relatedness, similar to correlation coefficients. Statements with a similarity value of .70 or higher were flagged as redundant, resulting in 140 pairs of overlapping statements. For example, *Ability to communicate effectively to convey a message* was flagged as redundant with: *Ability to choose an appropriate medium to convey a*

message; Ability to communicate information and ideas in writing so others will understand; Skill in using technology to communicate with others. Three researchers reviewed the 140 pairings independently, deciding whether to retain one, both, or neither statement based on redundancy. If two statements were deemed redundant, the more concise statement was kept. If statements reflected distinct KSAOs, both were retained. In cases of overlap where a statement was an exemplar, both statements in the redundant pair were removed. For example, “*Ability to use logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions, or approaches to problems*” was retained, while “*Ability to use adaptive reasoning*” and “*Ability to engage in sustained reasoning*” were removed. Statements flagged as redundant by all three researchers were recommended for removal. In cases of disagreement, further discussion led to consensus. This process removed 16 KSAOs, resulting in a refined list of 195 statements.

Following the removal of redundant KSAO statements, the final step was to review the remaining statements for project scope and specificity. Ideally, statements comprising the final list of KSAOs would be broad enough to apply to multiple groups of users across multiple types of technology, but not so broad that statements could apply to every user and every type of technology. For example, “*Skill in correcting a malfunction on an AN/UYK-128 (V) Automated Information System (AIS)*” was too specific, while “*Ability to expect the unexpected*” was too broad.

Review guidelines were established to help determine whether statements should be retained, revised, or removed. The default was to retain statements whenever possible, ensuring they were clear, within project scope, and could meaningfully differentiate performance. Statements outside the project scope, primarily those reflecting basic requirements for using technology (e.g., “*Ability to see long distances*”), were considered more as screening variables than performance differentiators and were flagged for removal. Five researchers independently reviewed the 195 KSAO statements, rating each for retention, revision, or removal. Ratings were combined into retain/revise and remove categories, with the majority decision (three or more reviewers) guiding the outcome. This process concluded with a refined list of 174 KSAO statements, forming the foundation of the competency model.

COMPETENCY MODEL DEVELOPMENT

Having refined the list of KSAOs, the next step was to develop the competency model. A competency model provides a structure by which the KSAOs could be organized in a meaningful way, specifically allowing us to identify the higher-order constructs comprising technological fluency. In revisiting the operational definition of technological fluency (*a competency consisting of cognitive and noncognitive attributes that enables individuals to creatively use, synthesize, and adapt with evolving technologies to enhance performance*), we noted there are two inherent layers to this definition. The first layer, which we termed *technological proficiency (TP)*, was related to the ability to quickly learn and use a new technology. The second layer builds off this foundation of proficiency and expands the required competencies to encompass the core of the *fluency* portion of the definition focused on the creativity, synthesis, and adaptability as it relates to technology. With both layers being critical components of the definition, we noted the preponderance of the KSAOs developed in the first literature review were reflective of TP, and we needed to conduct a more targeted effort to cover the added layer of fluency that enables Soldiers to innovate and combine pieces of technology to use in novel situations.

Given TF’s focus on creativity, synthesis, and adaptability, the researchers went back to the literature to identify KSAOs related to these requirements. We reviewed literature from the organizational sciences, specifically creativity (e.g., Zhou & Hoever, 2014), adaptive performance (e.g., Hennessey, 2010), and innovation (Anderson et al., 2014). Based on this review, the researchers asserted that the core of TF represents a Soldier’s capability to respond to a problem or situation by developing a novel technological solution. Thus, a process-based model was identified with three sequential steps, which themselves can be thought of as broad competency domains (i.e., clusters of lower-level competencies). These domains include (1) Problem Assessment, which represents a Soldier’s capacity to form a correct understanding of the emergent or anticipated problem, (2) Idea Generation, which represents a Soldier’s capability to think of possible technological solutions and assess their feasibility given available resources, personnel, and time, and (3) Idea Implementation, which represents a Soldier’s capability to execute the chosen solution. Although the three process steps are presented as distinct, they often overlap and occur simultaneously. Additionally, failures at later steps of the process may necessitate a return to a previous step creating a feedback loop. Approaching the identification and organization of KSAOs with this process in mind helped the researchers ensure that each step was sufficiently covered.

To organize the TP KSAO list into meaningful competencies, the researchers used an inductive approach to group KSAOs based on thematic similarity. The researchers identified a preliminary set of themes and competencies through natural language processing (NLP) and artificial intelligence (AI) analyses on the 174 KSAO statements. Employing BERTopic for topic modeling, several groupings (five, seven, nine, and 12 topics) were generated and reviewed to identify 17 preliminary competencies. Researchers then slotted the remaining 140 KSAOs into these competency categories and continued refining the list by removing statements deemed non-differentiating and resolving disagreements through discussion and finalizing the competencies. Researchers also added new competencies that were not present in the original list provided by the topic modeling approach. This process resulted in 122 KSAO statements across 25 competencies.

Further refinement involved researchers pulling the TP layer and additional TF competencies that were a product of the second literature review into one model, combining competencies where necessary while avoiding over-generalizing to ensure the model remains malleable into the future and that we do not eliminate any important component of the TF construct domain. Competencies were categorized into six higher-order groups, and definitions were drafted based on associated KSAOs, then aligned with existing frameworks like the Army Talent Attribute Framework (ATAF). This list can be found in Appendix B. The overall structure can be seen in Figure 1. The model consists of six higher-order categories with 31 competencies, each having one to seven exemplar KSAOs. The TP layer consists of 29 competencies, and the TF layer includes two additional competencies, leadership and risk-taking, as well as the problem-solving domains. These KSAOs are not intended to serve as an all-encompassing list for each competency, rather, they will serve as a representative list of the types of behaviors and actions associated with a competency.

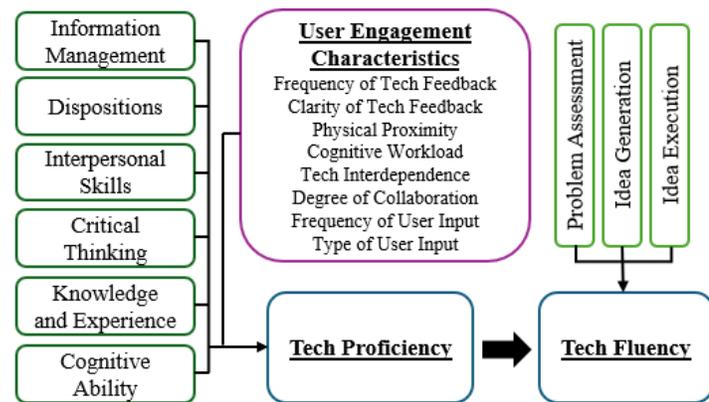


Figure 1. Overall Model Structure

Model Validation

The next step in this research is to validate the model. Currently, we have consulted with multiple SMEs to review the face validity of the model. Additionally, a survey and focus group protocol have been developed to assess content validity with a representative sample of Soldiers who interact regularly with technology to complete job-related tasks. In addition to responding to demographic questions including rank, MOS, and role, participants will be asked to provide a specific technology that they use at work. With that technology in mind, participants will then be asked to characterize the technology by providing ratings of the UECs. Next, participants will be asked to keep the same technology in mind, but to think about the different types of knowledge, skills, or abilities that are required to use or interact with this technology successfully. Participants will then be provided with the competency model and be asked to rate the importance of each behavioral indicator in the successful use of the tool/type of technology. This process will provide us with the data necessary to determine (1) if there are competencies and/or behavioral descriptions that are not applicable across our sample, (2) if there are clusters of user engagement characteristics that can be used to group similar technologies, and (3) if the groupings of similar technologies are related to a common set of highly important competencies. The efforts described here including validating both the competency model and the UEC list offer both a path forward for a linkage analysis between technology demands and requisite competencies.

FUTURE WORK: APPLICATIONS

One of the planned applications of this competency model is for Soldier assignments (i.e., classifications). It is understood that future technology and roles will change quickly; thus, assigning a Soldier who has a high propensity to learn new technology quickly to a military occupational specialty (MOS) that engages with technology frequently will enhance future readiness. Future research will include developing test blueprints that outline the content domains and weights to ensure assessments adequately reflect and cover important KSAOs. We will identify existing assessments that can be leveraged to assess various components of the model. Where there are gaps, new items can

be developed to include in the item bank based on the identified KSAOs. This effort will provide clear guidelines on what predictors to assess for classifying and assigning Soldiers to high tech roles. Additionally, it is worth noting that as part of this joint effort, ARL is collaborating with ARI to develop experimental platforms and design experimental tasks to assess TF. These tasks include interactive gaming scenarios incorporating artificial intelligence to predict performance and identify performance clusters. By analyzing these clusters, ARL aims to pinpoint the specific KSAOs that contribute to successful adaptation and optimization of new technologies. These novel assessment solutions offer exciting opportunities for the future of selection and assignment of Soldiers.

While the future of assessment is bright and can help ensure that warfighters are able to effectively execute their roles and missions in regard to TF, it is also possible to train them to ensure they have the necessary KSAOs and competencies. Training is an attractive solution given that technological fluency is an ability that will be required of Soldiers throughout the Army within the FOE; it is not limited to individuals within a specific MOS or career field. Selecting on competencies and KSAOs relevant to technological fluency is a viable option for Soldiers who have yet to join the Army, and strategic assessment and placement can be used to move some individuals into positions that match their skillsets. However, much of the force may benefit from additional training to ensure that they have the competencies and KSAOs necessary to effectively contend with and innovatively utilize technology within the FOE. Indeed, the education domain has studied technological fluency and demonstrated it can be increased through educational experiences (Barron, 2004; Barron et al., 2007). While it is worth noting that the definition of technological fluency in the education domain slightly differs from our operational definition, this research offers promise that the competency can also be developed in the military domain.

The identification of the KSAOs and higher-order competencies described in this paper is the first step in subsequently determining which, if any, of those KSAOs are currently being trained within the Army. Given that the KSAOs were partially derived from the ATAF, it is likely that at least some of the final KSAOs are important to the Army and to Soldiers in a broader context outside of technological fluency. Thus, it is likely that at least a subset of Soldiers are learning and growing these KSAOs already. For example, *“Ability to use linear, logical steps to analyze a number of already formulated solutions to a problem to decide on the correct one or the one that is most likely to be successful”* is a KSAO under the analytical thinking competency which officers demonstrate during their military decision-making process (MDMP). Therefore, a next step in this research is to conduct a training analysis to understand not only which KSAOs are already being trained throughout the Army but who is being trained on them. This analysis will be informative in at least two ways. First, if we can identify groups of Soldiers already being trained on the KSAOs necessary to be technologically fluent, then that knowledge can be used in conjunction with more strategic talent management initiatives associated with placement. Soldiers being trained in technologically fluent KSAOs could be placed in areas where there is a greater need for those competencies. Separately, however, this training analysis will provide information on the critical training gaps that exist.

Subsequently, recommendations can be made about the most salient KSAOs to train based on the gap analysis information. An important part of this analysis will also be to think critically about how to incorporate any new training recommendations into current training and learning opportunities. As outlined in *The Army Learning Concept for Training and Education 2030-2040* (TRADOC, 2024), future training and learning within the Army must create a continuous, career-long continuum of learning. Therefore, any recommendations on how to further develop the KSAOs and competencies needed by Soldiers to become and remain technologically fluent should consider taking advantage of opportunities within all domains of learning (operational, institutional, and self-development).

In summary, this research is a first step in delineating a structured framework to enhance the technological fluency of Army personnel, ensuring that they are well-prepared to operate and innovate with advanced technologies. By defining the necessary KSAOs and organizing them into competencies, we provide a foundation for evaluating and developing the technological capabilities of Soldiers. This framework and assessments may also be utilized by other branches of the military or industry professionals with similar goals. This competency model not only aids in the current assessment and training of Soldiers but also offers a flexible approach to adapt to future technological advancements. The insights gained from this research will inform the development of targeted training programs, fostering a technologically adept force capable of maintaining operational superiority. Furthermore, by focusing on cognitive flexibility and problem-solving skills, we equip Soldiers with the ability to seamlessly integrate new technologies into their operational practices. This comprehensive approach ensures that the Army remains agile and resilient in the face of rapid technological change, ultimately contributing to sustained operational success and strategic advantage.

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Appendix A. UEC List

Initial UEC List		Refined UEC List	
Physical Manipulation	Degree to which technology requires physical handling or manipulation to operate		
Frequency of Feedback	Feedback to user is continuous/iterative vs. discrete or absent	Frequency of Technology Feedback	The degree to which the technology provides feedback to the user
Type of Feedback	Feedback to user is explicit/clearly defined vs. implicit/ambiguous	Clarity of Technology Feedback	Feedback provided to the user is explicit/clearly defined vs. implicit/ambiguous
Physical Proximity	Location of technology relative to user (near vs. far)	Physical Proximity	Location of technology relative to user (near vs. far)
Autonomy	Degree to which technology is fully reliant on user vs. fully autonomous		
Cognitive Load	Degree of attention demand or cognitive engagement needed to interact with technology	Cognitive Workload	Degree of mental resources the technology requires of a person at any one time to interact with it
Technological Interdependence	Degree to which a user understands how technology is a standalone element vs. part of an integrated system of technologies	Technological Interdependence	Degree to which the technology is a standalone element vs. part of an integrated system of technologies
Interpersonal Collaboration	Degree to which technology can be operated by a single individual vs. requires team input/coordination	Degree of Collaboration	Degree to which technology can be operated by a single individual vs. requires team input/coordination
Prior Experience/Knowledge	Degree of prior tech-specific knowledge needed to operate the technology		
Attention Demand	The degree to which the user has to devote attention to the technology	Frequency of User Input	How often user must provide input to the technology
Structured Interaction	The degree to which the interaction with the technology is structured vs. unstructured	Type of User Input	How input is communicated to the technology, e.g., number of inputs, sensitivity
Physicality	How physical is the interaction with the tool, to what degree does elements of using the tool have physical element.		

Appendix B. TF Competencies and Definitions

Information Management	<p>1. Information Acquisition. Gathers information from various sources; identifies information that is useful and pertinent to fill knowledge gaps.</p> <p>2. Information Organization. Is familiar with information management systems and how to use those systems to organize and maintain information, data, and/or files.</p> <p>3. Information Evaluation. Evaluates the reliability of information as well as sources of information; uses information to conduct analyses, identify patterns, and draw inferences.</p>
Dispositions	<p>1. Achievement Orientation. Sets challenging goals and standards, is willing to give one's best effort, works hard to achieve difficult objectives, is confident and resourceful in striving for accomplishment.</p> <p>2. Technological Self-Efficacy. Is confident in one's ability to succeed, effectively meet challenges, and overcome obstacles when using technology.</p> <p>3. Positive Attitudes Toward Technology. Trusts and enjoys engaging with technology, fixing technology-related issues; finds value in using technology for various purposes.</p> <p>4. Learning Orientation. Seeks out learning opportunities, enjoys acquiring new knowledge and skills, and is comfortable applying new knowledge and skills on the job.</p> <p>5. Self-Awareness. Recognizes and monitors one's thoughts, feelings, and behavior.</p> <p>6. Tolerance for Ambiguity. Tolerates situations where the right goal or correct path to the goal is unclear, vague, or ill-defined.</p> <p>7. Adaptability. Modifies behavior or plans as necessary to reach goals. Is able to maintain effectiveness in varying environments with various tasks, responsibilities, or people.</p> <p>8. Openness to Experience. Tendency towards intellectual curiosity and willingness to try new things.</p> <p>9. Emotional Control. Acts rationally, displays a generally calm and even mood, maintains composure, and is not overly distraught by stressful situations.</p> <p>10. Risk Taking. Inclined to consider risky ideas; willing to cautiously engage in high-risk endeavors.</p>
Interpersonal Skills	<p>1. Communication Skills. Effectively communicates through written and spoken word.</p> <p>2. Teamwork. Works with others to achieve a goal or complete a task effectively and efficiently.</p> <p>3. Perspective Taking. Understands how people interpret events and interpersonal interactions.</p> <p>4. Leadership. Influences people, either formally or informally, by providing purpose, direction, and motivation to meet goals or complete tasks.</p>
Critical Thinking	<p>1. Problem Sensitivity. Identifies when something is wrong or is likely to go wrong. It does not involve solving the problem, only recognizing there is a problem.</p> <p>2. Cognitive Flexibility. Considers new approaches to solving problems, creates new plans and ideas, and initiates and accepts change and innovation.</p> <p>3. Systems Thinking. Considers the factors of a situation or a solution as a system of interrelated parts with inputs, processes, outputs and feedback.</p> <p>4. Abstract Thinking. Comprehends ideas that aren't tangible or concrete.</p> <p>5. Analytical Thinking. Analyzes information and applies general rules and logic to address work-related issues and problems.</p>
Knowledge & Experience	<p>1. General Technology Principles. Knows and is able to apply general information regarding technological principles, systems, equipment, operation, and repair.</p> <p>2. Specific Technology Principles. Possesses deep expertise in how specific types of technology works. Uses specialized technology effectively and/or is able to diagnose and correct problems with technology or machines.</p> <p>3. Technology Experience. Demonstrates a history of engagement with and/or regular use of technology (e.g., in childhood, grade school).</p>
Cognitive Ability	<p>1. Mathematical Reasoning. Uses the right mathematical methods or formulas to solve a problem.</p> <p>2. Verbal Reasoning. Reasons and draws conclusions based on verbal or written materials.</p> <p>3. Attention Control. Focuses and controls one's attention, processes multiple sources of sensory information while avoiding distractions, and identifies what information or sources require attention.</p> <p>4. Spatial Ability. Aware of one's physical location in relation to the environment or where other objects are in relation to oneself. Identifies and mentally manipulates the position of objects or points in space.</p> <p>5. Pattern Recognition. Detects similarities or differences in objects, words, or numbers.</p> <p>6. Memory. Retains and recalls information without using external tools or aids.</p>