4E Cognition into Verification, Validation, and Accreditation

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ABSTRACT

Since the early days of Verification and Validation, to the addition of Accreditation in the VV&A process, the goal has been to determine the credibility and appropriateness to the gaining organization of a system. As simulation-based training and learning technologies have continued to advance at a leap-ahead pace, the process utilized to evaluate them has not been able to maintain pace with the advancements in cognitive science. In particular, the gains in understanding of how cognition occurs as part of the overall learning process. This must be taken into account during evaluative processes, such as VV&A to identify true markers of ROI, in addition to marking areas for efficiency potential by realizing which areas of cognition are being most engaged by the system or technology in question. This paper will demonstrate areas of improvement to current and disparate DoD policies that govern and guide the VV&A processes for the service components and lay the foundation for the need to incorporate 4E cognition into these processes.

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INTRODUCTION

Since the dawn of simulation-based training the question has been raised, "does this do what it was intended to do?" While primitive, this is one of the underlying questions that is raised during the verification, validation, and accreditation (VV&A) process. These questions are aimed at ensuring the acquisitions process has stayed aligned with intent, policy, and ultimately value. The process has changed over time with revisions to the process, aimed at improvements and gaining efficiencies, but none have addressed the changes in the understanding of the role of the user, at the end of the line. What the process and those in the pipeline have not incorporated with the leap ahead pace that technology has advanced is the knowledge gains that have occurred in the cognitive sciences. Understanding the cognitive process is key to the goal of any trainer, in that knowledge is transitioned into the experience that is translated to the job. While much in the learning sciences has focused on this area, the key and critical gap in understanding is the relationship between the human, system, and environment. It is more than just human systems interaction (HSI), it is understanding the relationship of the mind, body, environment, and how these relationships play a pivotal role in the cognitive process in the training evolution.

4E Cognition is a recent breakthrough in the understanding of the relationship of how influences on cognition can work together and should be considered. 4E Cognition (4EC) ties together embedded, extended, embodied, and enactive cognition. While each of these areas of cognition has many considerations, the attempt with 4EC is to bring them under a common umbrella of research, unifying these four areas of cognition.

The VV&A process ties together the three processes of verification, validation, and accreditation. According to the DoD (DOD, 2018), verification is "the process of determining that a model implementation and its associated data accurately represent the developer's conceptual description and specifications." Validation is the process of determining the degree to which a model and its associated data provide an accurate representation of the real world from the perspective of the intended uses of the model. Accreditation is the official certification that a model, simulation, or federation of models and simulations, and its associated data is acceptable for use for a specific purpose. The purpose, then, of the VV&A process in Modeling and Simulation is to provide credibility to the system.

The implementation of 4EC into the VV&A process will improve credibility, by providing a structure and framework to consider human cognition as a means of improving the utility of a process, as the end means of the simulation is to ultimately train, and ensure learning has occurred.

In the case of the importance of 4E Cognition and its value for VV&A decision-making, we aim to (1) advance its basic premise to the M&S community and (2) offer it as a straightforward framework for adding more robust considerations into the VV&A decision-making processes. To do so, we start by offering a brief overview of both 4EC and VV&A as it applies to M&S. Then we demonstrate how the constructs of 4EC can be embedded into VV&A by offering examples of questions that are inquiry drivers supporting more nuanced examinations of each portion of the VV&A process. The paper closes with recommendations for how the 4EC principles can be immediately and long-term incorporated into VV&A processes to improve decision-making.

4E COGNITION

Embodied, embedded, enactive, and extended, or "4E Cognition", broadly refers to a family of constructs linked by a shared rejection of what advocates would consider limited views of the mind (Menary, 2010). While it is beyond the scope of the present paper to delve into the philosophical underpinnings, it suffices to note that 4E is neither limited to only four forms of cognition nor is it an explicit theoretical position. Rather, it is shorthand for a stance that

prioritizes a *cognitive system* rather than an *individual cognizer*. This point is critical for the discussion at hand. Current practices in VV&A have focused on decision-making processes in a manner that isolates decisionmakers and treats stakeholders as individuals. 4EC would reframe VV&A approaches by reconsidering each decision-point through lenses that consider cognitive systems, allowing for the adoption of learning and training solutions that are also being evaluated using the same frameworks.

To effectively apply 4EC, it is essential to understand this basic premise, and then the functions of each "E" and their contributions. It may be helpful to note that there are scholars who would add other "E"s to the list (e.g. ecological, emergent), but this core list is illustrative for the present purpose. We aim to offer the acquisitions community an opportunity to see that the VV&A process is designed to support improved decision-making, yet it if it has been built upon a flawed model of decision-making (that is, an individual cognizer model rather than a 4E model), it will always be impoverished. The following section briefly describes each "E", to provide clarity for its contribution to VV&A. It will probably be grossly unsatisfying to anyone seeking a deep understanding of these theories, as this review offers the broadest treatment to topics with much nuance and debate across cognitive scientists and philosophers of mind.

Embodied Cognition

Embodied cognition integrates the brain, body, and environment (Varela, Thompson, & Rosch, 2016). As the name alludes, this cognitive process is embodied, as it is in part constituted by the process occurring in the body outside the brain (Newen, DeBruin, & Gallagher, 2018). This may also include the interaction of extrabodily processes, which are occurring in the environment surrounding the body. Put simply, this is where the cognitive processes are dependent upon interactions with one's surroundings. There are three roles which the body may play in this approach of cognition. The body may act as a constraint, a distributor, or as a regulator of cognitive activity (Wilson & Foglia, 2011). Another way to view this form of cognition is as a body that requires a mind to function. Or, as a system, in which the body is responsible for providing inputs from the environment to the mind (Wilson, 2002). These inputs processed by the mind, in turn, put the body into action.

Embedded Cognition

Embedded cognition is a case of the interaction with the extrabodily process that occurs in the environment of the body system (Newen, DeBruin, & Gallagher, 2018). Embedded cognition involves a person's behavior being dependent upon the interaction of the person with their surrounding environment. The immediate environment surrounding a person contributes affordances to them which can enhance their perception, influence decisions, or enhance learning. Embedded is closely related to embodied cognition. The difference is that embedded focuses more on the physical, social, and cultural environments that are around a person, in the cognitive process (Suchman, 1987). This can be thought of as a means of interacting with the environment, gaining feedback, which provides input to the cognitive process, and most importantly, to make meaning of these inputs. Much like the body of a bat, which is interacting with the environment, but also using its body as a receptor (Dawson, 2014).

Extended Cognition

Extended cognition is the confluence of action and interaction with the environment, in which the activities may be manifested in the physical realm. This is the area in which a person takes advantage of affordances in the environment around them. According to Clark and Chalmers (1998), extended cognition may be thought of as the continuous interplay of actions in the environment and cognition. This assistance is in a way a form of scaffolding from the external environment and supporting instruments to assist with the internal cognitive processes, and makes use of the portions of human cognition which may be dependent on these external resources (Vaesen, 2011). This is one of the components of 4EC that may be the easiest to understand. The use of external objects, such as pen and paper, to assist in solving a problem is assisting in this cognitive process, or the use of a whiteboard to map out ideas or formulate plans. The cognitive process is being extended out into the environment.

Enactive Cognition

The fourth cognitive area of 4EC is Enactive cognition. This term is a reference to bodily and spatial activity as an aspect of cognitive development (Kaipainen, et al., 2011). This system blends the dynamic human and technological processes that create an embodiment of mind and technology. This form of cognition may seem familiar at first, because it is similar to enactive learning, which borrows from the forefathers of education, such as Dewey's learn by doing, and seen as enactivism, in which the key is the formation of meaning from the experience (Armendariz, 2019). The experience though is the interaction of the organism and the environment. Taken from the understanding of autopoiesis and Varela's (1997) study of cellular organisms and their re-production through the interactions of their environment. Extrapolating this further, it may be understood in terms of a user and their system, and the affordances which the system and environment provide to the user. Varela discussed this as a distributed effort among the reactions with the environment to be in a fluid state of seeking identity. This is like the user in a simulated environment, reacting to the affordances in the environment, blending with experience, to shape future behavior and understanding. This understanding is the operation of sense-making through the interactions with the environment, and understanding that the body plays a key role in this (Di Paolo & Evan, 2014). Gallagher and Lindgren (2015) call out, among key assumptions revolving around cognition, particularly that it is distributed across the mind, body, and environment. Further, this approach emphasizes the relevance of dynamic coupling and dynamic coordination across the same (Gallagher & Lindgren, 2015). The body is not merely a system of inputs and outputs, but a partner with the mind and body, more than a sensorimotor receptor, but a player in the cognition, or here – sense-making.

VV&A

The VV&A process is well known in the acquisitions community. The process is designed with end-users in mind. Through this process, the actions are aimed at addressing problems that the end-user may face, such as data availability, quality, and any issues of standardization that may arise (Sanders & Miller, 1996). The process intends to offer checks and balances throughout to reduce the risk along the way before getting to the end-user. The issue with the current process is that it tends to be bore-sighted on the systems as functioning instruments, and not-so-much as their role as tools for learning. However, without this process in place, there would be wider gaps in delivery to the end-user, such as non-functioning systems or systems that are incapable of doing what they were designed to do.

Overview

The process itself is not new and is in a constant adaptive state. For purposes of this paper, the focus will be on the VV&A processes as related to the US DOD. The gaps that the VV&A process was intended to identify, and fill came from the hard-learned lessons of the past. In the early stages, parts of the process were not completed, risks were not mitigated, or cases where no one questioned the validity of the tool (Sikora & Williams, 1997). The process is characterized by five applications: Research and Development; Analysis; Test and Evaluation; Production and Logistics, and Education, Training, and Military Operations (Youngblood & Pace, 1995).

The Defense Modeling and Simulation Coordination Office (DMSCO) is charged with the stewardship of the DOD guidance and policy, including the VV&A process. The process incorporates the three processes of VV&A.

Defining VV&A

The Military Operations Research Society (MORS) has been focused on the validation of systems for decades, which included leading workshops on the topics since the 1980s (Youngblood & Pace, 1995). The definitions that exist today have a lot to do with work that MORS put into them, combined with work at a symposium, SIMVAL, held in 1990 (Sikora & Williams, 1997). These definitions are laid out in the DOD Instruction (DODI) 5000.61.

Verification is defined as "the process of determining that a model or simulation implementation and its associated data accurately represent the developer's conceptual description and specifications" (DOD, 2018). Validation is "the process of determining the degree to which a model or simulation and its associated data are an accurate representation of the real world from the perspective of the intended uses of the model" (DOD, 2018). Accreditation is "the official certification that a model or simulation and its associated data are acceptable for use for a specific purpose" (DOD, 2018). The basic understanding of these can be described as verification is asking if the thing was built right; validation asking was the right thing built, and accreditation, if the thing is believable enough to be used (DMSCO, 2011).

The VV&A process shall be documented per requirements laid out in MIL-STD-3022 (w/change 1). These templates describe the key information required which demonstrates the ability for the intended use of the model and simulation, as well as for its reuse. The core set consists of the Accreditation Plan, the V&V Plan, the V&V Report, and the Accreditation Report. These processes (plans and reports) focus on setting the parameters that will be utilized for the assessment portions, methodologies that will be used, and importantly – the resources required to do so.

The Processes

The core outcome of the VV&A process is to figure out if the model or simulation is credible. The process itself is designed to determine this credibility. It does so by looking at the simulation's capabilities, accuracy, correctness, and usability – relative to the intended use (DMSCO, 2011). Simplified, VV&A could be viewed to determine how the simulation or model can address the problems or tasks that it was set to address. These may be split into V&V, and then Accreditation. V&V is focused heavily on the assessment of requirements for the model or simulation. The verification part of the process is focused on the design, implementation, and results, as the extent to which the simulation addresses the requirements laid out in the validation portion (DMSCO, 2011). Accreditation, being focused on suitability for intended use, is tied as well to the credibility and fitness of the system for use.

Current Publications

DMSCO, as discussed, is the lead facilitator for stewarding this process. However, there are organizations at the service level that address these topics as well, as individual policies. The various references, instructions, and directives serve to lead various facets of the M&S process, and specifically, the VV&A process. The governing document for the management of DOD M&S is found in the DOD Directive (DODD) 5000.59 (w/Change 1, 15 Oct 2018). The document helps outline responsibilities in the management and duties related to M&S, particularly after a realignment in 2018 at the Office of the Secretary of Defense (OSD) level. Key to the VV&A process is the DODI 5000.61 (w/Change 1, 15 Oct 2018), which establishes the policies, responsibilities for the VV&A of models, simulations, and associated data. Lastly, the MIL-STD-3022 (w/Change 1, 5 Apr 2012), which provides the templates for information, including the VV&A plans and reports.

These documents, as most policies at the strategic level, are direction light. While prescribing several responsible persons, and organizations, it leaves a bit of ambiguity in the totality of addressing the true outcome of the system, which ultimately to the end-user is to train and educate. Although some of these publications, as recent as 2018, there has not been much movement in addressing any gaps or chasms left by the leap-ahead rate at which technology, and thereby learning technology tools, are advancing. Much of the guidance is disseminated from the DMSCO via their website and the VV&A RPG. This leaves a wide gap in the implementation of policy, left to the various components of the DOD. This is evident in the policies which are present in the services, with most having their own: Navy (SECNAV Instruction 5200.46); Marine Corps (MCO 5200.28); Air Force (AFI 16-1001); Army (AR 5-11); and the Coast Guard (COMDTINST 5200.38A). The importance of having a glimpse into the numbers of policies indicating guidance and direction of VV&A in M&S is that part of the hurdle of implementing change, and consideration for integrating cognitive processes in would mean addressing such changes across these disparate policies, which is no easy task. More than likely, the change would need to be a top-down process, focusing on the DMSCO policies first and then funneling the changes down to the components.

4EC and M&S INTEGRATION

To date, there is no academic record explicitly linking decades of advancement in 4EC theory to DOD's M&S community, although one of the founding scholars in the field and arguably one of the people responsible for the term, Shaun Gallagher, has been affiliated scholar with the Institute for Simulation and Training at the University of Central Florida since 2011. So how, when emerging from the same community of thinkers and researchers that has also contributed so much to M&S, have the two lanes of thought remained so separate? One challenge has been that much of the published work from researchers like Gallagher remains somewhat isolated from the defense by being tested in seemingly unrelated fields, such as narrative and neurology. We aim to help DOD benefit from the theoretical and empirical work carried out in the past twenty years by applying the clarity they have gained to support VV&A decision-making.

One important thing to note is that, even though DOD may not be using the term "4EC", it is still applying 4EC in its M&S community. The demand for empirically-supported methods for improving learning and training has demanded that attention be given to more complexity.

M&S systems that "blur the lines" between humans and machines clearly are embracing the extended, embedded, and embodied aspects of 4E. The emphasis on adaptivity and human-to-human and multi-human-with-system networks are emphasizing enactive and extended cognitive processes.

Specifically, in military training and education where the service member becomes part of a system or a platform. Consider the aviator who is in colloquial terms, "strapping on a jet", or a sensor operator flying a platform halfway around the world, completely dependent on the inputs from a system physically not co-located, but driven physically by this operator, and at the mercy of cognitive processes of this operator.

In other domains where this emerging research is finding the root is in language acquisition or early learning of sounds. Learning programs that combine the environmental stimuli, and objects which assist in this understanding of the concept of sound and interaction have taken advantage of the interaction of the mind, body, and brain with affordances in the environment to enhance learner engagement (Schiavio, VanderSchyff, Kruse-Weber, & Timmers, 2017). The 4EC approach is also being used in psychology to understand various approaches from human-computer interaction (Hibbert, 2016) to alternate understandings of attachment theory (Petters, 2016).

4EC is already in M&S. If it is formally embraced to give format and support guidance, then stakeholders within the M&S pipeline will have the shared language to improve outcomes.

ADDRESSING THE GAPS

The gaps this paper set out to address are those with the policies that govern the M&S management, and specifically of the VV&A processes. In addition to these gaps, discussing the areas in which the bridge from acquisitions to training and education is lacking.

The Policies

The policies that are mentioned above serve to provide loose guidance with which parameters are set forth and services to utilize. They aim at setting the standard but do not drive at the standardization. In the beginning, as Williams & Sikora (1997) point out, the issues were in the implementation of a process, and the lack of standardization – in that parts of the process were skipped. This standardization may have suffered because of understanding. Considering the diverse nature of systems and technologies through the years that would have come through the acquisitions process, a common understanding would have been required. Among the DOD, this was an issue, as there was no common lexicon in the early stages, let alone as an M&S community (Sanders & Miller, 1996). Another issue was in being able to truly work the problem set. Often, there may be issues where there is not enough real-world data, or in some cases personnel, to evaluate and test the systems. These difficulties hamper the process itself, or prove too costly, due to a lack of resources (Sanders & Miller, 1996).

The policies do a decent job of ensuring that they are inter-related to the other policies, in which the services point back to the DODI 5000.61 and DODD 5000.59, but they are weighted in roles and responsibilities. In other areas of the policy, they mirror the requirements set forth by higher policies. Of the services, the Air Force (USAF, 2020) and Navy (USN, 1999) versions in which there was more of a breakdown of the processes and steps required. All the services provided latitude for subordinate commands to ensure they were meeting the VV&A requirements. Which is understandable, provided they adhere to the templates provided. Yet, this is only focusing on the instrumental portion of the issue – the M&S portion. Where is the concern for the end-user – the learner?

Why 4EC into VV&A?

The recent updates in policy focus on justification, costs, and resources. Consider this excerpt from the Coast Guard VV&A policy, "The cost of doing 'business as usual' has become prohibitively high" (USCG, 2013). The instruction goes on to point out the benefits of M&S from cost-savings, to risk mitigation, to instructional capability. This is the

vision that should be shared across DOD M&S professionals, to expand their view from the system they are assessing, to how it will be utilized – and why.

Today and tomorrow's M&S systems will operate in dynamic environments, amidst a continued rapid technological change and evolving battlespace. The capabilities of M&S allow for mission rehearsal, deliberate practice, and risk mitigation through the allowance of failure without costing human life. The outcome being that the participant is provided an experience which they will learn from and be able to apply to real-world situations. The combination of experience and learning, as well as practice, are the takeaways ultimately that will reduce the loss of human life. However, it must be considered how humans learn. Without this context, it can be difficult to ensure that an M&S system or tool is meeting the true needs of the end-user. Further, in an increasingly complex world of "bells and whistles" on M&S products, perhaps they are not needed, and 4EC may be able to tell you why, or why not.

Consider the example of military aviation. This is a popular example to think of in terms of M&S contexts because aviators may practice in the simulator and reduce any anxiety over failure, as it will less likely result in death in the simulator. Information in an aviation environment may be easily seen as distributed across the environment, brain, and in some cases the body, which makes it an even better thought example for 4EC.

Embodied cognition, as described earlier may have three roles, and one of those is that the body acts as a receptor in some of these cases. A key component of aviation is always maintaining situational awareness, through the integration of bodily inputs, perceptual inputs, or knowledge and experience which tie to assist in decision making in aviation (Green, 2017). A known in aviation is team dynamics and with it, the understanding of team cognition, which points out that collaboration is a factor of the interaction among the individuals (Bockelman-Morrow & Fiore, 2013). Considering embodied cognition is similar except that the team in this case is not a team of individual aviators, it is the body and brain of the aviator interacting, as a sort of collaboration, with their environment. One such interaction is the feeling of the onset of G-force. Fixed-wing aviators are trained to know this feeling, to perform actions to mitigate against G-Loss of Consciousness (G-LOC). Embedded cognition, in this same example, would then take an extrabodily action, combined with the environment to assist in cognition. An assistive tool to prevent G-LOC is G-suits that these aviators may wear. Upon detection of the onset of these forces, air bladders will inflate which attempts to keep blood flow from pooling in the lower extremities. These actions, in conjunction with the aviator's perceptions, allow for the aviator again, to make decisions to mitigate risk. Continuing with this example, the enactive cognition, in which it is building upon the experiential learning, and making meaning of them, and more importantly forming good habits that are necessary to overrule actions that may seem favored in the environment (Ramirez-Vizcaya & Froese, 2019). Learning to prevent G-LOC often begins with a chair or a beach ball and practicing the "hick" maneuver. Then aviators find themselves inside a simulated cockpit in a centrifuge where they practice their ability to stave off G-LOC. Finally, with extended cognition, the ability to offload cognition into the environment is a key assist. This is done quite often in aviation with the use of pocket checklists (PCL) or kneeboards with information, to reduce the working cognitive load of aviators.

Given these examples of where 4EC may come into play in the domain in aviation, it may draw a better line to how VV&A could benefit from the integration of 4EC. The consideration of importance is the requirement, or need of the learner, aligned of course with the return on investment for the service. What are the outcomes of the training evolution (or use of the M&S system) to the learner? Considering these outcomes may help determine what the M&S system should have, as well as the credibility given to the system after assessment. There are times when an aviator may need to utilize embodied cognition, as in the example, to feel the movement of the simulated aircraft, such as performing practice on specific aerobatic maneuvers. However, if the focus is on establishing a cockpit scan, full-motion simulators would not be needed, and perhaps no simulation at all, and just the model itself will work. When working to an understanding of design, as well as during the accreditation phase of what fidelity is needed of a system, it is key to know what the participant needs.

PROVIDING SOLUTIONS

The previous considerations were offered to contextualize the following suggestions. The present section outlines one low-hanging fruit solution and a series of farther-reaching efforts. In addition to recognizing that cognition as consideration is left out of the policies, is understanding where, why, and how 4EC aligns with VV&A.

Where to implement VV&A

As previously discussed, and outlined in the M&S VV&A Recommended Practices Guide (RPG) (2011), the wave tops outcome for VV&A is to establish credibility for a system. The processes put in place work through a problem-solving process to arrive at a decision based upon the analysis. Specifically, the credibility is derived from a handful of factors: Capability, Accuracy, Correctness, and Usability. One of the factors of usability is the use, of the simulation, "such as training and education" (DMSCO, 2011, p. 4).

The first major consideration of where is answered during the overall problem-solving process, as it is focused on capabilities of the system. The key is to evaluate through the lens of the end-user, with training and education in mind, and specific considerations for cognition. This is likely best placed during the V&V process, specifically during validation. Figure 1 below calls out two opportunities for placement of 4EC in the process. One of the key tasks during this phase is to "Validate Conceptual Model." This is an appropriate place in the process because it is here that the process ensures the model will "embody all the capabilities necessary to meet the requirements" (DMSCO, 2011, p. 15). Specifically, as consideration for these requirements should be iterative throughout the process, this step specifically works to ensure it. Another opportunity for placement could be during the Development phase, as the requirements are refined. This is where implementation can be affected by those in the roles we propose in the following section.

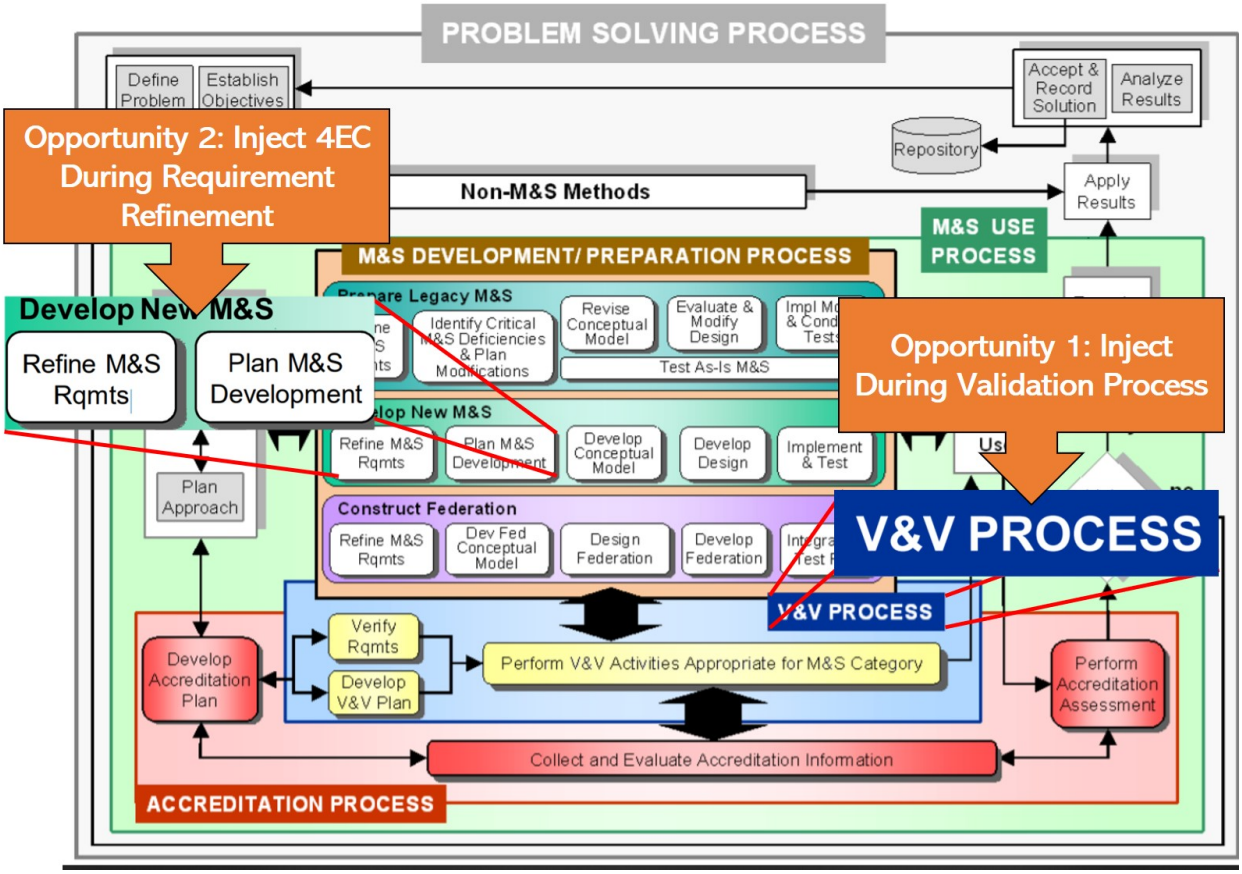

Figure 1. Proposed 4EC Implementation Points into VV&A (Original Figure (DMSCO, 2011))

Roles to Implement 4EC

The next natural question is who should implement 4EC into VV&A. This is a multifaceted approach. The roles, as they are defined are well thought out. They just additionally need these cognitive considerations. However, it aligns naturally with two of the specific roles – the User, and the SME. These roles are laid out in the DODI 5000.61 and are generalized in the RPG. The User is "the organization, group, or person responsible for the overall application." This is an important role, because this is the role that defines the requirements, establishes evaluative criteria, and will

accept the results. This role is the voting voice on behalf of the end-users, in the process. Since this role carries this vote, this role should also be informed to understand the role of 4EC, to be able to shape requirements and understand considerations that will impact how the end-user will utilize it upon transition. The second recommended role is that of the SME. The SME, though an auxiliary role, contributes to the overall process. Though without a vote in the process, this person fully understands the problem to be solved by the system and should be a voice towards requirements. The suggested change would be to ensure that the SME either has an appropriate foundation of training and education knowledge, or be augmented with a SME in the learning sciences to be able to speak to how requirements will affect cognition, learning, and knowledge transfer through the utilization of the system.

How to Apply 4EC into VV&A

Apply the 4EC constructs, at least informally, to VV&A evaluations. To that end, we offer the following table as a proof-of-concept for how the framework can support M&S experts to consider cognitive complexity in the VV&A process:

Table 1. How to Implement 4EC Considerations into VV&A

	Definition	Traditional Question	The questions to consider, based on 4EC			
			Embodied	Embedded	Enactive	Extended
Verification	Process of determining that a model implementation and its associated data accurately represent the developer's conceptual description and specifications	Are we doing this the right way?	How might the bodies and perceptual systems of the designers and developers be biasing design?	What aspects of the model or its data facilitate the learner/trainer practicing decision making leveraging resources from all three contexts? • Social • Physical • Environmental	What kinds of knowledge or skills will be generated through experience within the simulation?	What resources are provided within the simulation experience that may be included in users learning experiences?
Validation	Process of determining the degree to which a model and its associated data provide an accurate representation of the real world from the perspective of the intended uses of the model	Did we build the right thing?	How might variation in model perception impact learning/training outcomes?	What metrics are in place to assure the degree to which social, physical, and environmental contexts represented in the model reflect the relationship to cognitive behaviors expected in the real world?	What are meaningful metrics for anticipated emergent experiences? What are reasonable standardization schemes for emergent experiences given this simulation experience?	How might variation in access to and use of simulated resources affect user performance within the system?
Accreditation	Official certification that a model, simulation, or federation of models and simulations, and its associated data is acceptable for use for a specific purpose	Should it do what we need it to do?	What processes have been designed for this specific simulation system that helps assure the consideration of embodied experiences in learning/training?	Does the data collected on human performance clarify variance based on shifts in user access to cognitive resources in the following areas: social, physical, environmental?	How does the system capture objective data of new knowledge or skills that emerge through experience within the system?	Does the system accurately represent cognitive resource dependence in a manner that can reliably suggest similar dependence when used?

The incorporation of 4EC into the VV&A process may not be as easily done as change incorporation. As discussed, there are subordinate policies that feed on the DODI and DODD, that would likely need to update as a change to the

reference as well. There are additional hurdles of cultural change, design, and implementation of how to integrate 4EC specifically, and then the lasting change of being able to implement it to determine the results.

Cultural Change

Reviewing the policies that are in place for M&S management as well as VV&A, there are not many roles that are specifically tied to instructional designers, instructors, formal school managers, or those at the operational level. This means that an M&S tool or system could make it through the VV&A process as having met the criteria set forth ensuring that it is a credible system, yet it may be of impractical use for the end-user. In the end, if it is not used, the ROI is easy to determine.

Cultural change must occur for this to happen. Already, M&S technologies are dancing a fine line between a technology that allows for practice and the real thing – when it comes to cost. Building a training aid or tool that is only escalating in cost as compared to the real world, may produce inhibitions of avoiding the M&S product, if they can go and do "for real." Resource availability, such as range space and time, or ammunition budgets are reasons that M&S tools are desirable. In addition to mitigating risk, they allow for repeated practice without the additional cost. Secondly, the change must shift from focusing on the system itself away from replication of the system, but how it will be used, why it will be used – so that it will be used. Consider the example of an infantry squad attempting to learn hand and arm signals to improve formations during movement. Would they need an expensive weapons system in their hands, or adorning their body to do so? Or would they be able to do with a dummy rifle or even a long stick? The outcome would be focused on the hand and arm signals. To build knowledge for the understanding of hand and arm signals, would the M&S community need to develop a 3D or Virtual Reality representation of a battlefield and simulated others? Or could it be as simple as a digital application that would improve base knowledge of terms, and positions that they could use on their electronic devices? Creating an enactive learning environment in which the participant is more active can increase the comprehension of the information that is presented to them (Gallagher & Lindgren, 2015). Those stewarding, managing, and facilitating the VV&A process should bear that in mind as they are determining the credibility of the M&S product, as well as it's potential for use, which ties directly to the overall ROI.

All or Nothing

The 4EC approach that this paper is suggesting should be added to the VV&A process is not an all or nothing approach. What should be built as a solution is a model that draws out the benefits and consequences of the inclusion of these approaches? Based on the outcomes that are needed by the end-user for the learner, being able to decide during the early stages of acquisition if those needs are being met. Further, and more specifically then, those assessing would be able to determine whether the learning needs will be met by the M&S product. Ideally, this would be built as a model or framework which would be implemented into the DODI 5000.61. The result, though, should be a practical tool or instrument such as a checklist to be utilized by designers of these products and known to assessors, but be able to take advantage of cognitive processes, to increase overall ROI of products.

THE CHANGING ENVIRONMENT

The year 2020 has been unprecedented to date. The early weeks of March 2020 saw rapid decisions and movements to physically distance people from each other, reduce physical movement and interaction, and the movement of work, K-12, post-secondary, and even military training to remote capabilities. Immediately within days, the world was faced with a rise and fall of successes and failures. These were in capabilities where organizations had to ensure that there was enough equipment to allow for the move. Networks across the world were tested for their strength against a rising number of those working from home, as well as home learners. Video teleconferencing systems were tested for their capability to host courses, meetings, webinars, etc. while attempting to rapidly figure out privacy and cybersecurity concerns. In the early stages of the response to COVID-19, it seemed that there were updates by the hour of products to use, or not use based on lessons learned through experience. Why were these lessons learned at a rapid rate during this time of crisis though? Likely because though these products and systems were vetted, they were not vetted with these uses in mind. A teleconferencing application was likely developed in mind with handling business transactions and meetings, but perhaps they had not considered their system being used by a 3rd-grade class to cover elementary social studies. Likewise, many DOD systems were stress-tested, pitting capability against the same privacy and cybersecurity concerns. The movement to the use of all available products to continue to train, educate, and sustain

the force may have opened the aperture for understanding where some further gaps may be concerning how these products are used to train and educate.

The Human in the Loop

The crises that COVID-19 brought, demonstrated gaps in all areas of life, from emergency preparation of basic needs supplies to the disparity of resource availability among households across the world, be it access to a computer or the internet. Assumptions and things that were taken for granted were exposed during the crisis.

In the modern technological world, it is important to understand it from a 4EC perspective. The growing availability of technology and information at one's fingertips further embeds the populace with the technology. People become embodied in an environment that integrates their body, personal devices, and the environment to make decisions and to alter behavior. The crisis has also highlighted other areas of basic human needs, of interaction and communication with other humans. Utilizing technology to improve these interactions or provide a means for it helps build a framework for understanding what this means to our ability to process.

CONCLUSION

The understanding of cognition is growing day-by-day as scientists and psychologists work to understand how the human operates within the world around them. The 4 E's of cognition demonstrate through their approaches to understanding how this integration works, and why it may be of benefit. Understanding that the mind is not singularly in charge of gathering inputs, processing them, and then initiating action should go a long way to M&S product developers, evaluators, and managers. The environment in which the product will operate must be considered, the interaction of the human with the system, in that environment, must be considered. The affordances which the product intends to provide should be considered. But those are considerations. The real change needs to be into the VV&A process, as these products are being assessed and evaluated for their utility and credibility to do what they were designed to do, but also to achieve the ultimate outcomes of enriching the experience of the end-user whether that is the deliberate practice of a known skill, acquisition of a new skill, or simply to gain new or helpful habit patterns. All of which the goal to transfer to the real-world application. Until cognition is considered in VV&A, there will be a continued risk of a well-built and well-designed system reaching end users that works, but does not meet the needs of the end-user, and threatens the utility of the product. 4EC approaches, when considered, can shed light on the tools that humans use to learn, the support they glean from the environment, and even point to areas where efficiencies may be gained, as with extended learning. The choice to not include these considerations in the VV&A process is a choice to reduce efficiency in training and education and contribute to ambiguity of the true ROI.

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