Transforming Training Requirements Analysis: A New Model

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ABSTRACT

The current time-consuming, costly process of defining training requirements and designing an appropriate training system is inefficient and outdated. We propose the application of a stream-lined, time-sensitive model to support current rapid acquisition needs. It expeditiously assigns training objectives to an expanded realm of training technologies. The proposed model, built upon existing research, evaluation, and best practice guidance by the DOD, has three interrelated concepts: (1) an algorithmic assignment process, rendering consistent, data-determined technology requirements; (2) a re-conceptualization of training media as technology affordances; and (3) a reorientation of the task list toward cross-utilization of training system data and learning objectives. Re-conceptualized, training technologies' affordances are used to match training requirements to specific training capabilities. The model standardizes the identification of training tasks in terms of scope, classification, and characteristics, and retains data in user-friendly formats for future analyses. This function-based approach to defining tasks and objectives facilitates the transfer of existing data to future analyses, and creates a hierarchal task constellation structure of related and necessary tasks and training objectives.

To date, the model has been applied to eight DOD platforms, successfully assigning training technologies to learning objectives. The platforms are both manned and unmanned aircraft, some on the forefront in terms of technological advancement and human interaction. Resulting training requirements correspond to established training modalities such as computer-based training, part-task trainers, and flight training devices. The model supports rapid acquisition because it reduces the time necessary to conduct training requirements analyses through the standardization of data and data collection, the allocation process employed, and its decisions points. These features heighten transparency and increase customer visibility into the assignment process, resulting in improved customer confidence in training system recommendations. This paper will discuss the model and the results of its application to requirements definition across DOD platforms.

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INTRODUCTION

In February of 2008, The ASTA Group, LLC (ASTA) was contracted to identify avenues of efficiency in the application of a standard Training System Requirements Analysis (TSRA). {The TSRA is a study of the various elements of a platform's (e.g. an aircraft, vessel, vehicle, weapon) training system, including task performance, cost, etc., conducted in order to recommend training methods.} A fourteen-month project was undertaken, during which a technology allocation model was developed, tested, and refined.

Goals of the project included the development of a standardized, consistent, and transparent objectives-media assignment process inclusive of current training technologies. Transparency allows customer evaluation of assignment outcomes based upon clear and substantiated data rather than subjective information and reliance on historical practices. The model was applied to training task data from eight separate aircraft and their training systems. The model was evaluated after each application by the research team and government customer and revised as necessary, in accordance with customer specifications.

Training Technologies and the Military Paradigm

At a basic level, training can be conceptualized as knowledge instruction followed by skill and performance instruction, which builds on the initial knowledge base to train task performance. Again at a basic level, training can be accomplished using presentation methodologies (such as a classroom lecture), followed by instructor-led instruction using the operational tools of the operational setting. Historically, military training has gravitated toward these two ends of the spectrum, based largely on experience, but this rationale does not necessarily render the most effective training. For example, almost all tasks could be trained in an operational aircraft, but its use would not be the most efficient, safe, or even effective means, as the aircraft would provide a level of interactivity unadvisable for some tasks.

The middle of the training spectrum has evolved incrementally, and encompasses training technologies that have developed to address steps along the training process. These incremental solutions begin to develop skill and performance while continuing to build the knowledge base. Use of these middle technologies improves training efficiency and trainee performance once that person reaches the operational environment.

The developed model is based on the belief that given sufficient capabilities and fidelity, nearly all training tasks can be accomplished through computer-training or simulation. Furthermore, the ever-increasing capabilities of training technologies offer training opportunities not otherwise available in the classroom or operational environment.

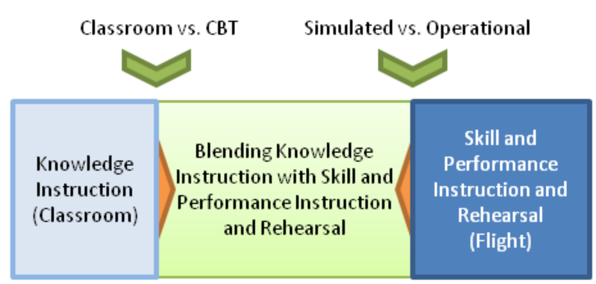

Figure 1: The Continuum of Training

The transition from classroom instruction through training technologies to the operational environment can be viewed as movement along a continuum (see Figure 1). Along this continuum, boundaries separating training technologies and classroom and operational environment are imprecise. Therefore, assignment requires the consideration of factors other than past experience to determine the best training method. For example, if a task can be trained in the classroom or through computer-based training (CBT), which is the best way to train it? Similarly, if aircraft training can be conducted on a simulator as well as on the aircraft, which training method should be used? To answer these questions, model calculations routinely identify the technology-based training solution. By design, the model's calculation criteria "push" the assignment toward the middle of the continuum. It does this because training technologies, in general, offer greater flexibility, capability, and specificity than either classroom or aircraft training. These incremental solutions along the middle of the continuum will more likely be matched to specific training requirements.

The model also assumes that the final training system configuration will be partly dependent upon factors that lie outside of its current configuration, such as cost and throughput. These factors are training system dependent and vary according to the circumstances associated with each specific training system.

MODEL DESCRIPTION

This model is based upon the hypothesis that specific task characteristics and learning objective criteria can be used to determine the appropriate level of technology required for training. These characteristics and criteria provide discriminatory power for training technology assignment within the model. To align with standards used by the government customer, they are consistent with those defined/identified through DOD guidance (MIL-HDBK 29612).

The model emphasizes technology rather than media to increase its capability to assign complex training mediums to 21st century tasks. This emphasis corresponds to the evolution that has taken educational technology research through a series of stages, focusing, in turn, on learning content, instructional message formats, and the interaction between computers and students (Winn, 2002). The research field is now oriented toward the study of learning in complete, complex, and interactive learning environments, which has become necessary with the advent of technologies that allow such learning.

Traditional training models have focused on a selection of discrete media to train learning objectives. However, we envision training technology choices along the continuum, with each point along it representing a change in training capability that has specific characteristics associated with it. Therefore, the model described herein is a technology allocation model (TAM). The TAM is operationally similar to an Objectives-Media Analysis (OMA) Model, except that it is built upon a continuum of training technologies rather than discrete media units.

This model utilizes technology affordances to bridge the gap between training requirements and training capabilities. The concept of "affordance" was originally introduced as a theoretical construct of ecological psychology (Gibson, 1979). According to Gibson, an environmental affordance represents the complementarity between an object in the environment that allows (or affords) a particular action and an individual who is able to perceive that the object allows that action and is capable of performing that action. In other words, the affordance perspective maintains that both internal (what the individual knows or perceives) and external (what the environment provides) information determines behavior (Rabinowitz and Shaw, 2005).

The affordances of a training technology refer to what the technology allows the user to do or experience when using it (e.g., portability, sensory capabilities, interfaces and controls, etc.). Affordances may be associated with cognitive as well as psychomotor learning. Affordance combinations and variants determine the interactivity "levels" of a training platform as well as capabilities available for the person utilizing it. Since technology affordances are not limited to a specific training device or situation, the use of affordances, rather than devices, allows the model to be applied across various platforms and to various operational settings.

Determining Interactivity Levels

Research conducted twenty years ago demonstrated improved learning through training technology applications, but also showed that it was the quality of the instructional design that affected learning outcome, not simply the incorporation of technology (and media) (Bloom, 1984; Lysakowski and Walberg, 1982). Today, the advancement of technological capabilities has changed the importance of technology's role. Training technology provides interactivity capabilities not otherwise available in a training system.

The critical feature of simulation for learning is the student's ability to experimentally act on the learning environment. Theoretically, simulation allows students to construct understanding for themselves through their interaction and manipulation of information and materials presented through the simulated environment. Early research in this area demonstrated that student control, with guidance, over how they learned could produce significant learning gains (Carrier, Williams, and Davidson, 1985; Dwyer, 1985; and Johansen and Tennyson, 1983).

In addition to its effectiveness, a second significant feature of simulation particularly relevant to the present discussion is that it allows students to do things they would not be able to do in the real world. Well-constructed simulations have been shown to be both motivating and effective for learning (see Brown, Bransford, and Cocking, 1999).

Based on this research, the model assumes that interactivity is a strong predictor of training efficacy and efficiency. Because learning and training research has shown that interactivity between a user and their learning environment contributes to training effectiveness, interactivity was selected as a primary determination criterion for model calculations. This selection was also based on government guidance about how different learning objectives relate to various levels of interactivity (see MIL-HDBK 29612-3A, Table 25, p. 46). This guidance classifies interactivity as:

- **Passive** refers to technologies and media that treat the trainee as a passive recipient of information, and includes presentation of information for knowledge acquisition.
- **Limited Participation** includes technologies and media capable of providing drill and practice.
- **Complex Participation** includes technologies capable of providing complex branching paths based on student selections and responses.
- **Real-time Participation** requires capability for real-time simulation of performance in the operational setting.

As presented in Table 1, varying levels of interactivity are capable of supporting designated types of knowledge, skill, and attitude (KSA) learning. KSA are specified for individual training tasks in the model.

This guidance was used to develop a model framework that converts levels of interactivity into a continuum of training capabilities. Model calculations rely partly on K and S components. Initial analysis revealed that the component A lacked discriminatory power in determining interactivity requirements, and it was removed from the initial model design. When considering S levels during design and texting phases, all levels, with the exception of perception, implied the performance of a task that included a physical or motor component. Consequently, it was necessary to differentiate interactivity levels that included motor capability from those that did not.

Using the above guidance and current research on technology interactivity, the team constructed categories of training technologies along the continuum. These categories, including their associated devices, products, or environments, are reflective of interactivity differences. Levels 1-4 vary according to the above guidelines and do not have motor capability. Levels 5-8 also vary according to the guidelines, but include motor capability necessary to rehearse a physical training task. Differences in interactivity represent differences in computer/technology functionality as well as variations in physical or motor training capabilities.

Table 1: Recommended Interactivity Levels for Training based on KSA Learning Levels

	Knowledge					Skills							Attitudes				
Interactivity Level	Factual	Rule Learning	Procedure Learning	Discrimination	Problem Solving	Perception	Readiness	Guided Response	Continuous Movement	Mechanism	Adaptation	Origination	Receiving	Responding	Valuing	Competence	Innovation
Passive	■	■	□	□	□	■	□	□	□	□	□	□	□	□	□	□	□
Limited	■	■	■	□	□	■	■	■	□	□	□	□	■	■	□	□	□
Complex	□	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Real-time	□	□	□	■	■	□	□	□	■	■	■	■	■	■	■	■	■

Recommended ■
Not Recommended □

Source: MIL-HDBK 29612 3A, Table 25, p. 46

Levels 1-4 have physical capabilities limited to what is typically available through commercial off-the-shelf (COTS) hardware options (e.g., desktop, laptop or handheld computer, computer displays, and networking capabilities). These training products typically use input devices limited to a mouse, keyboard, gamepad, or joystick. These products also have sound/communication capability as determined by the hardware and software configuration, and may be delivered through any COTS accessible media (i.e. CD, DVD, flash memory) or interface (internet, intranet).

Levels 5-8, on the other hand, add equipment, interfaces, or settings that simulate operational devices and environments. These capabilities are provided to allow training of physical and/or motor aspects of a task. Capabilities may range from something as simple as a handheld weapon mock-up to a fully physically and virtually immersive environment.

Model levels are determined by interactivity capabilities that include both cognitive and psychomotor affordances. This basis allows for innumerable combinations of affordance-requirements matches without pigeon-holing requirements to a specific training device or environment. On the other hand, the levels do correspond to training devices familiar to the training community. This correspondence is illustrated in Figure 2, below.

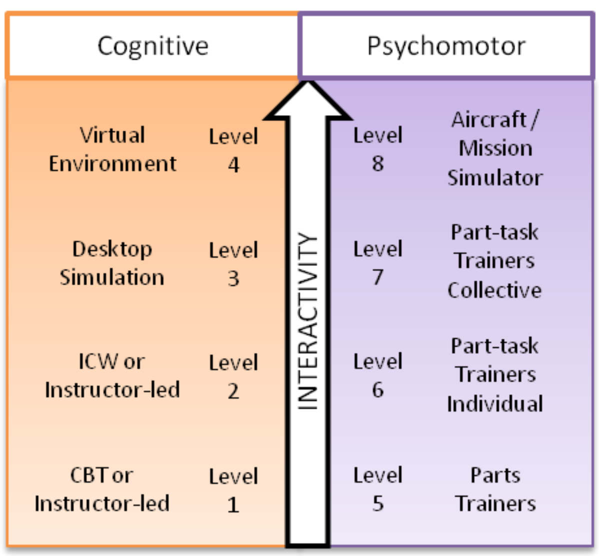

Figure 2: TAM Interactivity Levels and Training Devices

Determining Affordances

Individual task data and characteristics are used to determine the required affordances necessary to train a task or a learning objective. These affordance requirements, in turn, determine the appropriate training technology combinations that afford those capabilities to users. Thus, affordances define training needs and match those requirements to training technologies.

There are countless affordances. However, the sensory experiences and types of interactivity affordances promote are much less numerous—human beings utilizing technology have only a limited number of senses and avenues to perceive them. Therefore, not every affordance added discriminatory power to model calculations. The vast array of affordances was refined into a condensed list that makes task assignment to technologies as efficient as possible, while providing discriminatory power.

The affordances currently employed in the TAM are associated with a task's operational setting and interfaces, operational cues, and sensory cues. Data elements pertaining to operational cues, interfaces, and controls are routinely gathered through Subject Matter Expert (SME) interviews. These task data elements together form a set of operationally determined affordances, and are referred to collectively as system affordances.

System affordances are allocated to each task and learning levels based upon the required operational affordances and cues. System affordances define the sensory stimulus requirements of the training device(s) assignments and are combined with interactivity level assignments to provide training recommendations. Together, the system affordances and interactivity level assignments define the appropriate training device or environment (i.e. classroom or aircraft) requirements.

Determining Input Data

The assignment process (see Figure 3 on the next page) requires sufficient task information for input and determination of training recommendations. Input data encompasses task performance requirements of users, task complexity, and system interface requirements. Task characteristic input utilized includes task performance difficulty, cues, user interface and controls, knowledge levels (K), skill levels (S), and whether or not collective performance of a task is required to train properly. These were selected to align with task data collection guidance provided by MIL-HDBK-29612-2A.

Cue data determines the sensory stimuli required for each training task. There are affordance requirements associated with using each platform's systems, performing maneuvers, and completing operational tasks. The training technology selected must possess these affordances in order to support training of tasks associated with systems, because the systems must offer the user sensory stimulus to perform the tasks.

Cues associated with task performance contribute to the identification of the affordance requirements, such as visual or auditory signals, or crew communication, for systems. The following cues have been included in the model: audio; haptic; motion; olfactory; tactile; verbal; visual (both on-screen and outdoor surroundings).

Figure 3: Task Characteristics and TAM Utilization

System affordances—affordances associated with aircraft systems, maneuvers, and cues—are assigned to each task or learning objective individually, based upon the systems used and cue prompts associated with tasks.

Technology Assignment Process

The Model Flow Chart (Figure 4) depicts the flow of data beginning with task data collected through document review and SME interviews. Data elements relevant to knowledge and skills form the basis of the set of interactivity determined affordances. Operational data elements form the basis for the (operationally determined) system affordances. These features are used to define task (or learning objective) training requirements.

Affordance clusters, defined by task cues, interfaces, and control requirements, are organized and structured into similar categories that are used to define specific training device requirements.

While it was anticipated that a set of pre-defined affordances could be pre-assigned to training devices, it was discovered that only some of the affordances could be pre-assigned. Additional affordance requirements emerged directly from task data. This added a dynamic component to the model, and will allow for future expansion and applicability of the model across platforms. Technology affordances can also be expanded to accommodate emerging technologies.

Database Configuration

The model was developed in Microsoft Access® 2007 according to customer specifications. It is designed for local installation but positioned for easy adaptation to a web or server environment. A custom user-interface allows data entry, reporting, and exporting of task lists or other information. Data may be entered directly via the user interface, or imported from Microsoft Excel® files.

This configuration allows the archiving, revision, and future use of collected task data. The current database contains task lists and associated data for seven USSOCOM platforms. The archiving and exporting model capabilities allow for ready utilization of existing data for future TSRA needs, reducing the time and costs associated with data collection in accordance with study goals..

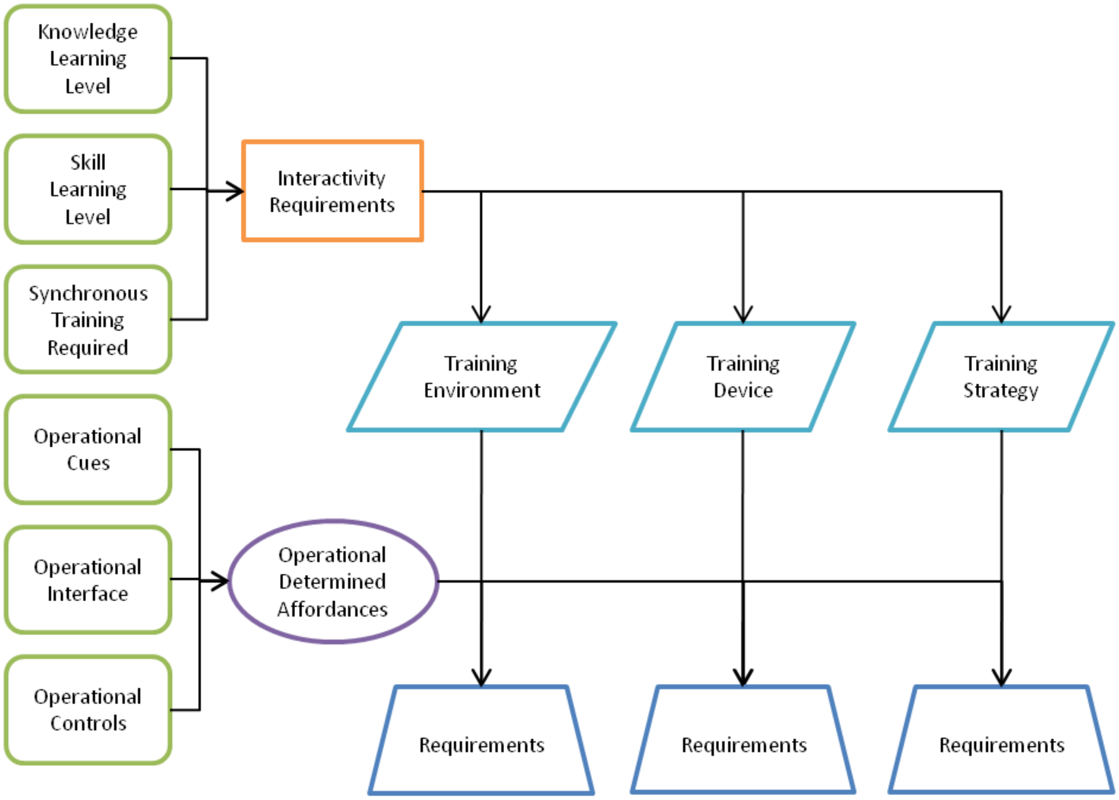

Figure 4: Model Flow Chart

MODEL VALIDATION AND FINDINGS

The model was designed and validated utilizing training task data from four separate platforms over the course of fourteen months. The four study platforms were: CV-22; MC-130W Dragon Spear; RQ-11B Raven; and ScanEagle. These platforms represent both manned and unmanned systems, including tiltrotor, conventional fixed-wing, and small unmanned aerial vehicles. The model was simultaneously used in four additional, separate TSRA efforts during part of the project period, providing additional data for development and validation. The validation process is summarized in Figure 5, presented on the next page.

To develop and initially test the TAM, the model was applied to CV-22 training task data. This platform, chosen by the customer, had an established training program to serve as a baseline for comparison. Data was collected by the research team. Specific CV-22 training task characteristics were examined and applied to the model to identify both task performance and technology affordance requirements. An algorithm-based task assignment process utilizing task data and characteristics, affordances and interactivity levels of training technologies, and operational interfaces, controls, and cues was developed and refined through the application of this initial data.
The first run of the computation-based algorithm successfully determined training technology utilizing task characteristic data. The model identified training tasks that were best suited for observation, experience, and mentorship.

Model processes and output were assessed by members of the customers' team, who, though not experts in model design and quantitative analysis, were experts in training system design and development. Their assessment indicated that the model indeed performed as it should, and assigned tasks to technology as anticipated given the existing CV-22 training system. This evaluation established face validity for the model, the confirmation that assignments were made in a logical and rationale way.

After initial model validation, steps were taken to incorporate customer feedback concerning assignment process and resulting recommendations. The most significant customer feedback after conclusion of the first analysis concerned the fact that aircraft training was not included as direct output of the model, but was determined through post–hoc analysis of cost and

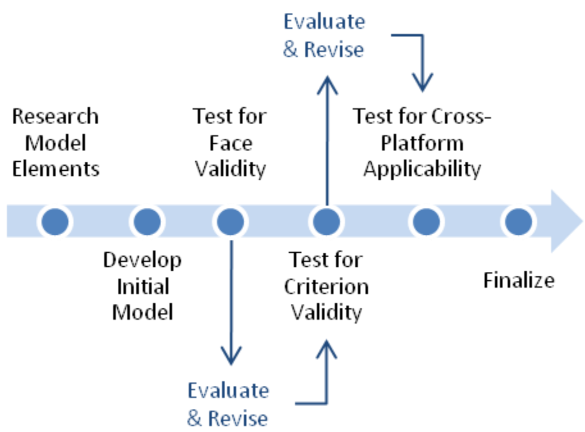

Figure 5: Model Development Process

throughput requirements. Due to this feedback, the model was revised to include aircraft training as an output category.

The customer was also concerned that model assignments included, in some instances, recommendations for more than one training device or strategy, and expressed a preference that only one, the "best recommendation" be provided. This feedback was also integrated into the model to force a single recommendation. Finally, the model algorithm was adjusted to provide better alignment of training tasks to training recommendations, as determined by face-validity analysis.

With face validity established, the team was ready to test criterion validity. In other words, test if and how well the model's set of input variables—developed using CV-22 task research—could be used to predict or determine the training system for another platform, utilizing the new platform's task information as the input data for each variable.

The second study platform was the MC-130W Dragon Spear, a platform that incorporated mission sets from several USSOCOM platforms. This real-world application presented new challenges to the development and validation process. First, it included multiple crew positions, which required new interpretations of output data. Secondly, the study required the amalgamation of task lists from a number of various platforms. In addition, final configuration options were undecided at the study outset.

The TAM was successful in allocating specific training recommendations for each Dragon Spear learning objective. The results were also consistent with the CV-22 results—similar training tasks and learning objectives across platforms were allocated to similar training recommendations, establishing a measure of criterion validity.

After the study was complete, the algorithm process and allocation output was again evaluated with the benefit of an additional data set. This evaluation resulted in further revision to refine and improve the accuracy of the allocation results.

The third platform analyzed during this study tested the model's cross-platform applicability. Though all data used in model development came from manned aircraft systems, the model successfully allocated training tasks of two unmanned aerial systems when applied to their data. The two systems had operational differences significant enough to provide meaningful analysis and comparisons. The most significant difference, which affects training requirements, is that the aerial vehicle of one training system was hand-launched while the other was mechanically launched. Subsequent analysis confirmed both face validity and criterion validity of the assignments for each unmanned platform.

Time and Cost Effectiveness

Goals of the project included reducing the overall time and cost of a TSRA. Time and cost savings are realized through task list database integration into the Objectives Task Analysis (OTA) output model. Part of the purpose of the project was to provide the customer with a centralized database of tasks that they could draw from to conduct subsequent analyses—a tool that they could use, and retain and grow its content.

By far, the most time consuming part of each analysis conducted during this project (barring model development) was the process of constructing a task list. Many tasks are similar among platforms. Many platforms are built upon the same frame, or are only differentiated by updated equipment. Task lists, therefore, are often constructed by amalgamating selected tasks from existing training task lists for other platforms. These task lists exist as materials that must be located by the government customer, funneled through bureaucratic chains, and examined to select appropriate tasks for the platform being evaluated.

By providing the government customer with a centralized "template" task list, from which one can choose tasks to generate subsequent task lists, time is saved in constructing them. The customer can produce its own task list when necessary, thus eliminating the need for the contractor to locate, gain access to, and analyze existing lists as part of the TSRA. This translates directly into immediate cost savings.

Additionally, the government customer owns the information input into the model database, and retains use of that data in the future.

These considerations are in line with the overall goals of the study. However, model refinement is an ongoing and iterative process. Further model refinement and the addition of more tasks to the database will grow the model's utility and produce a tool that optimizes user friendliness.

LESSONS LEARNED

Final training system configuration depends upon factors that lie outside of the model's current configuration, such as cost and throughput. These factors are training system dependent, and vary according to the circumstances associated with each system. The model favors technology-based training solutions and it assumes that the final training system configuration will be dependent, in part, upon factors that lie outside of the model's current processes. For these reasons, the team recognizes the need for development of additional modules.

One area for additional research and model development will include greater specificity regarding requirements data input into the model. During affordance identification, the team condensed the affordance list for model processing efficiency. As discussed previously, because sensory capabilities are limited, as are interfaces of current technologies, many affordances were repetitive and failed to add discriminatory power to model calculations. However, the capability of the model to output lists of specific training technology requirements for tasks presents the possibility of utilizing expanded affordance data to generate system engineering data output from the model. This may potentially improve cost and time efficiencies of training system design and development.

Secondly, cost is often an ad-hoc, situation-dependent, and volatile aspect of training system development. Cost consideration is currently outside the scope of this model's task characteristic, data-based algorithm capability. However, an add-on module, incorporating quantitative cost considerations may significantly enhance utilization. A third aspect for added-on calculation capabilities is throughput.

At present, the model utilizes sensory data input, motor-capability, and interactivity in its processes. The study team frequently encountered allocation decisions which may have been otherwise addressed through a systematic analysis of cognitive affordances. Therefore, the team recognizes the need to further explore the discriminatory power of cognitive affordances as an additional component of the allocation process.

ACKNOWLEDGEMENTS

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